CONTRIBUTIONS

FROM THE

CUSHMAN FOUNDATION

FOR

FORAMINIFERAL RESEARCH

Volume VIII, Part 3
July, 1957

Contents

1957

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FOR FORAMINIFERAL RESEARCH

VOLUME VIII, PART 3, JULY, 1957

171. SEASONAL OCCURRENCES OF LIVING BENTHONIC FORAMINIFERA IN SOME TEXAS BAYS

BY

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ABSTRACT

Seasonal collections were made from 32 stations in San Antonio, Mesquite, and Aransas bays during August and November, 1954, and January, March, May, and June, 1955. Studies of the seasonal living populations confirm the previously established faunal difference between the upper and lower bay areas. Living **Ammobaculites salsus**, a typical upper bay form, averages 27-59 specimens per station in the upper bay and 2-3 per station in the lower bay. The total living population in the upper bay is several times larger than that in the lower bay. This is attributed to the influence of the Guadalupe River bringing in food and/or trace materials conducive to high production. Populations in the lower bay are similar in size at all seasons. In the upper bay, on the other hand, the largest standing crops occurred in November and January. The reasons for this are obscure, but it is suggested that lower temperatures may cause reduced activity of bacteria in competition for food.

Plotting of distribution of sizes in **Streblus beccarii** at all stations shows a wide range of sizes at all seasons at all stations. This suggests that the population is composed of a wide range of age groups and that reproduction is occurring at frequent intervals. Plots of some species of **Quinqueloculina**, on the other hand, indicate seasonal reproduction and subsequent growth in average size of the specimens in some populations. Values for coefficient of variation generally are higher near the Guadalupe River than at other places in the lagoons.

INTRODUCTION

The area covered in this report includes San Antonio, Mesquite, and Aransas bays on the central coast of Texas, and extends from approximately 28° 20′ to 28° 47′ N. Lat. and 76° 30′ to 97° 03′ W. Long. The sedimentology of this area has been discussed in a comprehensive report by Shepard and Moore (1955), the basic patterns of dead foraminiferal populations have been described by Parker, Phleger, and Peirson (1953), and the living populations of Foraminifera at one season of collecting have been described by Phleger (1956). The purpose of the present report is to examine the distributions of living Foraminifera collected at two-month intervals for one year, and to attempt to discover the seasonal aspects of production, growth of the population and variability in population size distribution.

The field and laboratory work were supported by American Petroleum Institute Project 51. Final copies of the illustrations were drafted by Jean Peirson Hosmer.

Contribution from the Scripps Institution of Oceanography, New Series, No. 935; Contribution from the Marine Foraminifera Laboratory, No. 25.

DESCRIPTION OF AREA AND METHOD OF STUDY

Many of the features of this area have been described previously (Parker, Phleger, and Peirson, 1953; Phleger, 1956; Shepard and Moore, 1955). The bays are separated from the open ocean by a sand barrier island breached by only one perennial inlet at Aransas Pass in the southern corner of the area. The bays are very shallow with Mesquite Bay less than about 4 ft. in depth, San Antonio Bay averaging 5 to 6 ft., and Aransas Bay somewhat deeper. The Guadalupe River flows into the northeast corner of San Antonio Bay. The sediments are generally silty clays in the center of the bays grading into a narrow zone of sand at the margin: the area is traversed by numerous, elongate, shell reefs.

Thirty-two stations were occupied in Aransas, Mesquite, and San Antonio Bays during six seasons for one year; locations of the stations are shown on Figure 1. The periods of collections were August 26-29, 1954, November 9-11, 1954, January 5-7, 1955, March 7-9, 1955, May 2-4, 1955, and June 28-30, 1955. The stations are in all the principal foraminiferal assemblages previously established and give a reasonable coverage of the area. Surface-water samples for salinity and temperature observations were made at each station occupied during November, January, March, May, and June. Sediment samples were collected with a short coring tube previously described by Phleger (1951). The top 1 cm., comprising approximately 10 ml. of wet sediment, was taken from each core and preserved in neutralized formalin for study of Foraminifera. Neutralized formalin may break down into formic acid which will dissolve calcareous tests of Foraminifera in preserved material. A small amount of sodium carbonate was added to each sample to safeguard against solution and the pH of stored samples was determined frequently.

In the laboratory the sediment samples were washed over a screen having average openings of 0.062 mm. Specimens of Foraminifera alive at the time of collection were identified by the rose Bengal stain method

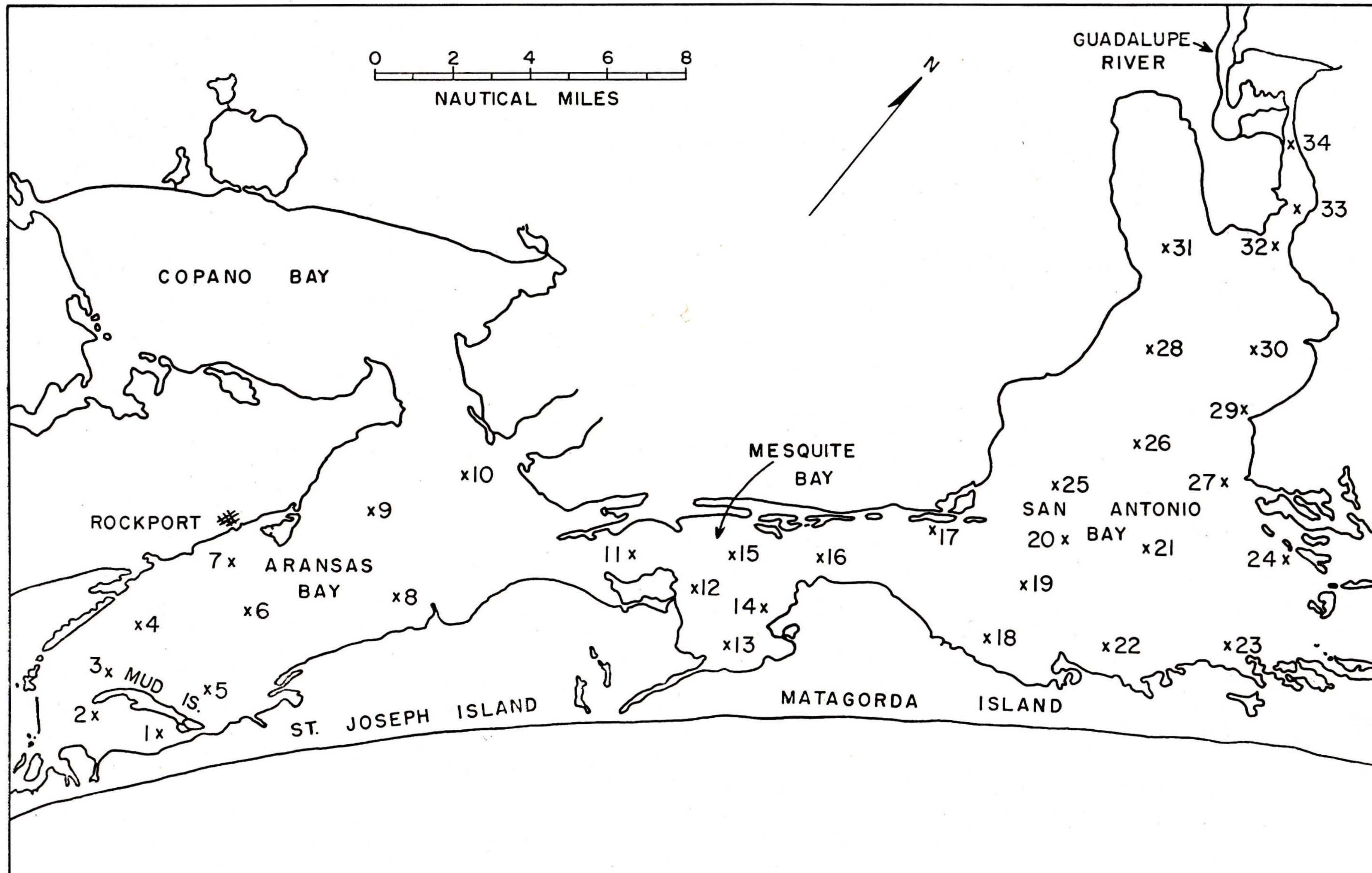

FIGURE 1. Locations of stations.

described by Walton (1952). Living specimens were counted and in addition the maximum dimension of each living specimen was measured with a microscope micrometer disc. Sizes of specimens were listed according to divisions of the micrometer disc; each division is 0.025 mm. All measurements and detailed faunal data are on file at the Marine Foraminifera Laboratory, Scripps Institution of Oceanography. Illustrations of the species reported are in a previous paper (Parker, Phleger, and Peirson, 1953).

Temperature and salinity data have been summarized by Phleger (1956). Temperatures in Aransas Bay are reported by Hedgpeth (1951) to range from 13-31°C and the actual extremes over a long period of time probably are 5-10°C greater. Temperature data collected by the writers in 1954-55 are given in Table 1. Temperatures on November 9-11, 1954, ranged from 18-20°C. In January, 1955, measured temperatures were somewhat lower. They ranged from 14.7-21.6°C but were 15-18°C at most stations. In March temperatures averaged 16-18°C; these stations were occupied during a time of overcast and relatively cold weather when temperatures are expected to be somewhat lower than average. By May temperatures had risen to 25-26°C and in late June they were 29-30°C.

These surface temperatures are believed to give an approximate measure of the temperatures at all depths in the lagoons since the water is shallow and usually has daily wind mixing. There is obvious diurnal warming, as shown by average afternoon temperatures being 1-3°C higher than morning temperatures. These data may represent approximately normal yearly distribution but extreme maxima and minima apparently were not recorded.

Salinity data are discussed in terms of chlorinities in a previous paper (Phleger, 1956). Salinity data collected by the writers are listed in Table 2. In general, lowest salinities occur nearest the mouth of the Guadalupe River in Guadalupe Bay, and the salinities of both middle and lower San Antonio Bay are consistently lower than those of Aransas and Mesquite Bays. Salinities in Guadalupe Bay are quite variable depending upon runoff, and range from 2 o/oo to 24 o/oo. In upper San Antonio Bay the salinity usually is 33 o/oo or less, and in lower San Antonio Bay generally more than 33 o/oo. The highest salinities usually are found in Mesquite Bay; this was especially apparent in June, 1955, when the range was from 41.5-42.6 o/oo.

UPPER AND LOWER BAY FAUNAS

A faunal difference between upper and lower bays was demonstrated in previous papers (Parker, Phleger, and Peirson, 1953; Phleger, 1956). The present data confirm this and give further insight into the faunal differences in these two environments. In studying the faunal data it was apparent that the stations could be divided into two general groups, each of which seemed to be a faunal unit. The stations in Aransas, Mesquite, and lower San Antonio Bays which may be termed "lower bay" are 1-18, 21-24. "Upper bay" stations are 19, 20, 25-29, 31-34; station 30 is not included because its faunas are somewhat different from other stations; station 34 also is distinctive because of its very large populations and usually is not included.

Table 3 lists average total living populations in the upper and lower bay stations and average number of *Streblus beccarii* and *Ammobaculites salsus* at the various seasons of collection. An examination of these data shows that the average population per uniform size sample in the upper bay ranges from 188 to 352. The average number of specimens in the lower bay is much smaller, ranging from 53 to 106 per sample. The most striking difference between the different parts of the bay is the occurrence of *Ammobaculites salsus* which ranges from averages of 27-59/station in the upper bay to averages of 2-3 per sample in the lower bay. It is apparent that this species is better adapted to the upper than the lower bay. The average populations of *Streblus beccarii* in the upper bay were four to ten times larger than those in the lower bay at the times of sampling.

The living faunas in Aransas, Mesquite, and lower San Antonio Bays are also different from those in upper San Antonio Bay in containing several species which are more or less restricted to the lower bays or have generally higher frequencies in the lower bays than in the upper bay. These species are as follows:

Nonionella atlantica Cushman
Quinqueloculina funafutiensis (Chapman)
Q. lamarckiana d'Orbigny
Q. poeyana d'Orbigny
Rosalina floridana (Cushman)

Eponidella gardenislandensis Akers and *Miliammina fusca* (Brady) appear to be characteristic of upper San Antonio Bay, especially at the stations near the Guadalupe River.

There are some species typical of the open-ocean, nearshore environment which occur in the dead populations in lower San Antonio and Mesquite Bays, but have not been found living here. Living specimens of these species, however, occur in lower Aransas Bay. The following is a list of species which occur at station 23 in lowermost San Antonio Bay and which are not represented by living specimens:

Elphidium discoidale (d'Orbigny)
E. galvestonense Kornfeld

E. incertum mexicanum Kornfeld
Hanzawaia strattoni (Applin)
Massilina peruviana (d'Orbigny)
M. protea Parker
M. sp.
Quinqueloculina rhodiensis Parker
Q. wiesneri Parr

The following additional open-ocean species are not living in Mesquite Bay but are represented in the dead population:

Bigenerina irregularis Phleger and Parker
Reussella atlantica Cushman
Rolshausenia rolshauseni (Cushman and Bermudez)

The presence of *Palmerinella palmerae* Bermudez in the dead populations of the lower bays is not well understood. This species is not an open-ocean form and it has not been found living in the bays. It is suggested that this is a marsh form, apparently indigenous to the barrier island, and that it has been transported into the bays.

The locations where these open-ocean dead forms are found are on the inner side of a continuous barrier island and at a distance of several miles from permanent inlets. Most of the species have been found living in lower Aransas Bay, which is near an active inlet, and appear to indicate invasion of open-ocean water carrying the open-ocean species of Foraminifera. It is suggested that the presence of the dead open-ocean species in lower San Antonio and Mesquite Bays indicates either the former presence of inlets or occurrences of "wash-overs" over the barrier island during a storm such as a hurricane. Presence of wash-over channels on the barrier island in this area can be seen from the air. An inlet leading into Mesquite Bay is open occasionally. Open-ocean forms may have migrated into this area through the inlet and died out when the inlet became restricted or closed. It is also possible that some specimens were blown into the lower lagoon, but this seems less likely than in areas where more persistent winds of appreciable velocity blow from the ocean.

The distribution of the Miliolidae in the bays seems to be related to the type of substrate. They appear to prefer a sand or shell bottom, and numerous instances of living forms with their pseudopods attached to sand grains have been observed in the preserved samples.

Occurrences of living specimens of the various species are listed on Tables 5-10.

SEASONAL POPULATIONS AND VARIATION

There is no uniform relationship between size of living population and season of collection at the lower bay stations. Each of these stations seems to have its season of largest population more or less independently of nearby stations and no generalizations can be made about time of largest standing crop in this part of the area. In upper San Antonio Bay, on the other hand, the highest populations were collected during the winter season, November and/or January, at stations 26-29 and 31-34. This is also shown in the data for the average populations in the upper bay (Table 3) where the average populations for November and January are almost twice as large as those for the other seasons in the upper bay. In the lower bay there is a peak in the average population size in May but this does not occur at many stations.

Size-distribution histograms of the individuals of *Streblus beccarii* and *Ammobaculites salsus* were made at most stations, since these species have the highest consistent frequencies. Representative frequencies of sizes are shown in Figures 2-5. Size distributions for these two species show that there is a generally large range in size at all stations at all seasons, shown by the lateral spread of the histograms, and, moreover, that the spread in distribution is similar at all seasons at the same station. This suggests that the populations of these species are composed of mixed age groups. It appears, therefore, that reproduction in these populations is occurring at frequent intervals and during all seasons of the year. This conclusion is in agreement with results obtained by John S. Bradshaw (personal communication) on laboratory cultures of *Streblus beccarii.* He finds that under laboratory conditions this species will reproduce every four to eight weeks within the ranges of salinity and temperature to be expected in the environment represented by the Texas lagoons.

In contrast to this, some species of *Quinqueloculina* show evidence of seasonal reproduction. This is best shown by the size distribution of *Q. poeyana* at station 3 (Fig. 6) where there was a large population of relatively small specimens in August, 1954, but by March of the following year the total population had decreased and the average size of the individuals had increased. In the following June the average size of individuals was again relatively smaller. This suggests that summer is the season of reproduction for this species at station 3. The other *Quinqueloculina* species in Figure 6 also show some evidence of seasonal reproduction. Other species of living Foraminifera were not present in sufficient abundance to warrant plotting their size distributions.

It seems reasonable that the variability within an environment should be reflected in the genetic composition and morphology of individuals within a population. Species which are flexible in their adaptability are expected to inhabit more variable environments than those which are less adaptable. An index of variation of a population may therefore be an indication of the variability of the environment in which a population lived. The variation of size distribution within a population is expected to be somewhat different for different species and may differ because of the population growth stage, frequency of reproduction, and mortality rate.

An index of variation may be a useful tool in indicating the relative variability of the environment where a population lived and may be a clue to the actual environment. The Pearson coefficient of variation, $V = 100\ \sigma \div M$, has been calculated for living *Streblus beccarii* in all samples where the populations were large enough to be statistically significant. The coefficient of variation is an empirical measure based on the standard deviation, σ, and the mean, M, where the smaller coefficient numbers indicate less variation than the larger ones. Measurements of maximum diameter were used and the analysis is restricted to *S. beccarii* because the most reliable measurement data were obtained for this species.

Calculated coefficients of variation, V, are listed for *Streblus beccarii* on Table 4 along with the average values for V at all seasons at each station (V is given to the nearest whole number). The range for V is 17-43, and the range for the average of V is 20-34. In San Antonio Bay there are two geographic areas of average values. In the uppermost bay stations, 30-34, there are relatively high values of V, ranging from 30-34. These stations are nearest the Guadalupe River where there is most effect from the variable runoff of the river, the salinities are most variable, and it appears that there is most variation in the environment. South of station 30 the average values for V are lower, in the range of 20-26; most of the lower average coefficients of variation are confined to the lowermost bay at stations 17-19 and 22-24. There is some indication of higher values of V in the northern half of Aransas Bay, nearest the entrance to Copano Bay, than in the lower area, but the differences are not so marked as in San Antonio Bay.

In a previous paper on living Foraminifera from this area (Phleger, 1956) the ratio of living to total populations was calculated and estimations were made of relative sedimentation rates in these lagoons. Suggested relative rates of sedimentation on this basis were shown to be very low in the lower lagoons and significantly higher in the area in upper San Antonio Bay near the Guadalupe River. Live-total ratios have been estimated in the present samples and they appear to have the same orders of magnitude and to be distributed in the same pattern at all seasons as in the previous study of one season.

Duplicate samples were collected at two stations during March, 1955, in an attempt to discover whether collection methods were adequately sampling the living population. In four samples collected from station 15 the living population varied from 19-23 and the faunal composition was essentially the same. Five samples were collected at station 21 which had total populations varying from 10-19 with the larger population samples having more rare species but essentially the same basic faunal composition. These data probably indicate that a fairly good sample of the population is taken. It is suggested that the error of sampling probably is within the error of laboratory analysis of these populations.

DISCUSSION

There are significant differences between upper and lower bay faunas. There are fewer species at most stations in the upper than in the lower bay and the open-ocean species generally are restricted to the lower bay. The latter may be attributed to the immediate influence of open-ocean water invading through the inlets. The presence of higher living populations at all seasons in the upper bay than in the lower bay is more difficult to explain. It appears that the differences must be related to the influence of the Guadalupe River which is most pronounced in upper San Antonio Bay on the basis of salinity distribution. There is a marked increase in the size of the standing crop near the river with the largest population at all seasons at station 34 in Guadalupe Bay nearest the river mouth.

High populations near river mouths are established off some of the effluents of the Mississippi River near Main Pass and Pass a Loutre (Phleger, 1955). Living populations are higher in the direction of river mouths on the continental shelf off San Antonio Bay (Phleger, 1956).

The river-borne materials and/or factors which influence high standing crop, and probably high production, are believed to be numerous and are not known. Possible river influences are as follows:

1. An abundance of particulate food may be introduced by river water into a marine environment to which the populations are adapted.

2. Abundant nutrients may be introduced by river water into the marine environment and cause high production of plant materials which provide food for the Foraminifera.

3. It has been observed by Lankford that largest benthonic populations occur off the Mississippi River where there is a combination of high organic production and fast detrital sedimentation. It has been suggested that the sediment, which is very fine grained, may bring in attached detrital food on which the Foraminifera feed. It is interesting in this connection

that the highest populations are in San Antonio Bay in an area where the present sedimentation rate appears to be higher than elsewhere in the area.

4. It is well-known that the composition of dissolved salts in river water is quite different from that in ocean water. River water may also introduce trace materials, both organic and inorganic, which are conducive to growth of populations. Soils contain many such materials, and this fact is useful in laboratory foraminiferal cultures where soil extract is an essential ingredient for the living diatoms which are used as food in many such cultures.

No obvious explanation has been found for the higher populations in upper San Antonio Bay during November and January than at other seasons. Rainfall and meagre runoff data have been examined for this period and there do not seem to be any significant differences from other seasons. The salinities near the river mouth in November, 1954, ranged from approximately 25-34 o/oo and in January, 1955, were approximately 2.2-6.4 o/oo. At other stations in the upper bay salinities were essentially the same at both seasons and similar to salinities in the upper bay at other seasons. Water temperatures during this winter season, on the other hand, were significantly lower than at other seasons, being 18-20°C in November and 14.7-21.6°C in January. This infers that the low temperatures may have been conducive to growth of a large population. It has been suggested by D. L. Fox (personal communication) that the large populations at that winter season may be caused by lessened activity of bacteria in competing for the food supply.

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TABLE 1. Surface water temperatures in °C

Sta.	Nov.	Jan.	March	May	June
1	19.6		16.5	26.5	29.7
2	19.9	14.7	17.7	26.5	29.7
3	19.3	15.3	18.2	26.5	29.7
4	19.4	15.2	18.8	26.3	29.8
5	18.1	15.3	19.0	26.0	29.5
6	18.1	15.3	19.5		29.3
7	18.1	15.5		26.5	29.3
8	18.4	15.0	18.5	26.5	30.0
9	19.1	14.9	18.5	26.3	30.2
10	20.1	14.9	17.3	26.5	30.5
12	19.3	21.3	19.0	26.5	29.7
13	19.2	21.0	18.8	26.0	29.7
14	19.1	21.1	18.0	26.7	29.5
15	18.8	21.6	18.5	26.0	29.5
17	19.0	21.4	16.5	25.5	29.0
18	19.2	19.3	16.8	26.0	29.2
19	18.6	19.1	17.0	26.0	29.0
20	18.7	18.9	16.8	25.5	28.5
21	18.4	18.8	16.5	25.7	28.8
22	18.3	19.7	16.4	25.5	28.8
23	17.8	19.0	16.0	25.5	28.3
24	17.9	20.0	16.0	24.5	30.3
25	18.6	16.5		24.5	28.7
26	18.7	16.4		24.7	29.0
27	19.1	16.9		25.7	30.3
28	19.1	16.5		25.3	29.2
29	19.3	16.7		26.0	29.5
30	19.2	16.4		25.3	30.0
31	19.2	16.3		25.0	29.5
32	18.8	15.8		25.5	29.5
33	19.3	15.1		25.5	29.5
34	19.0	15.5		25.5	29.5

TABLE 2. Surface water salinities in o/oo

Sta.	Nov.	Jan.	March	May	June
1	36.51	36.59	34.42	35.41	40.82
2	36.35	36.30	33.78	35.67	39.60
3	36.35	36.12	34.04	35.60	39.52
4	36.68	36.09	33.33	35.47	39.30
5	36.63	36.00	33.52	35.82	39.46
6	36.56	35.89	33.15	36.25	39.33
7	34.47	35.91	33.46	35.16	39.18
8	36.18	36.16	33.73	35.88	41.17
9	35.22	35.37	33.84	36.75	41.34
10	35.48	35.42	34.22	35.94	41.07
12	36.77	37.04	33.08	36.18	42.51
13	36.51	36.82	32.29	34.34	42.55
14	36.53	36.75	31.67	36.17	42.60
15	35.10	36.68	31.73	36.43	41.57
17	33.58	35.52	29.31	33.30	41.76
18	34.66	35.15	33.95	34.11	36.99
19	33.83	34.72	33.87	33.69	36.67
20	34.21	34.57	32.09	33.04	34.23
21	34.69	34.24	31.72	34.75	36.85
22	33.64	35.24	33.18	34.52	36.96
23	33.69	35.41	33.13	35.32	36.01
24	33.19	35.41	33.14	35.34	36.31
25	32.32	33.07		33.16	31.26
26	33.11	30.66		33.05	28.05
27	33.52	34.51		32.84	30.82
28	30.48	29.33		30.90	29.22
29	33.48	35.37		34.08	31.24
30	34.22	32.54		30.59	28.60
31	28.96	27.61		32.09	26.71
32		6.35		24.90	4.92
33	24.85	3.00		14.83	2.56
34		2.19		15.75	2.30

TABLE 3. Comparison of populations of living Foraminifera in upper and lower bays

TOTAL POPULATION

Season	Av. no./sta. in lower bay	Av. no./sta. in upper bay
August, 1954	53	198
November, 1954	65	352
January, 1955	85	330
March, 1955	55	no samples
May, 1955	106	188
June, 1955	60	236

LIVING POPULATIONS OF *Streblus beccarii* (LINNÉ)

Season	Av. no./sta. in lower bay	Av. no./sta. in upper bay
August, 1954	15	92
November, 1954	22	266
January, 1955	32	158
March, 1955	10	no samples
May, 1955	24	91
June, 1955	18	106

LIVING POPULATIONS OF *Ammobaculites salsus* CUSHMAN AND BRONNIMANN

Season	Av. no./sta. in lower bay	Av. no./sta. in upper bay
August, 1954	3	48
November, 1954	3	40
January, 1955	3	53
March, 1955	3	no samples
May, 1955	3	27
June, 1955	2	59

TABLE 4. Coefficient of variation (Pearson) in *Streblus beccarii* (LINNÉ)

Sta.	Aug.	Nov.	Jan.	March	May	June	Average
1			25	28			26
4		26	17				22
5	20	24	23	24	23	22	23
6	40	25	24		27	24	28
7	24	33	21		20	17	23
8	32	22	18	26	22	32	25
9	28	34				27	30
17	15	24	29	32		25	25
18	26	25			22	20	23
19	19	18	17	25	20	20	20
20	26	20	21	13	25	18	20
22	21		22		24		22
25	24	21	23		23	34	25
26	23	29	35		21	24	26
27	19	18	32		18	22	22
28	24	23	18		31	23	24
29	28	22	19		24	26	24
30	35				29	27	30
31	23	24			30		28
32		32	34		36	26	32
33		31	32		43	29	34
34		34	31		31	35	33

STATION	1	2	3	4	5	6	7	8	9	10	12	13	14	15	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
TOTAL LIVING POPULATION AUGUST, 1954	25	12	158	70	119	65	42	52	100	45	38	24	9	8	68	100	340	24	11	38	50	24	266	428	73	131	79	117	104	317	216	1186
Ammobaculites dilatatus	1				2	1	1		1			1				34	6				1			2		5	1	2				
salsus & vars	1				37	4	1	2	6	3					1	6	52	2	1	1			185	20	5	14	1	13	67	112	122	767
spp.																													1			
Ammoscalaria pseudospiralis	3	1	1	5		2	9	4	2	5	3	6		1	7	9	37	1	1	9	3	8	2		20	1	21		3			
Bolivina lowmani								1																								
striatula					1		1				1	2			1	1		1		1			3				1					
Buliminella elegantissima																																
Elphidium delicatulum	1		2		5				3	1					2		2	1	2	1				9	2	3	1	3			5	21
discoidale																																
galvestonense			3																													
gunteri	4		4	4	4	2	2	10	3	7		1	2	1	1		9						5	9		2	4			1	6	14
incertum mexicanum																																
cf koeboeense														1									12									
matagordanum	1				3	2		2	4		1				38			3			1		49	9		2	2	5		2	1	
poeyanum					11	2	5	2	16	8	2		1	1	2		4	3	3		2			9	1	10	1	1	1	1		
spp															1																	
Entosolenia sp.									2								1															
Eponidella gardenislandensis	1														1								3	10		1				70	21	231
Massilina peruviana																																
protea																																
sp.				4																												
Miliammina fusca																																4
sp.																1																
Nonionella atlantica																	2															
Quinqueloculina cultrata			1	1												2	2				1								1			4
funafutiensis		1	5	5			1		1		27	7	2	1							1											
lamarckiana	2	2		2																												
poeyana		6	103	11										1		8	18		1		2						1					
rhodiensis	2		1	4																												
seminulum			2	2							1	2																				
wiesneri			18	1				1																								
spp.			6	4			1				1					3	4											1				
Reophax nana																																
Rosalina floridana	1						3			1																						
Streblus beccarii var. A	2	2	7	9	35	40	15	26	59	19	2	3	3	2	11	12	157	13	3	23	31	15	99	354	39	85	28	82	24	95	37	81
beccarii var. B	2		2	2	21	12	3	4	3	1			1		1	23	13			3	6		8	6	6	8	15	4	6	13	10	11
Triloculina sidebottomi	2		3	14								2			2	1	33										3	6	1	23	14	53
Other spp.	2			2																	2											

TABLE 5. Distribution of living Foraminifera in surface sediment samples during August, 1954.

STATION	1	2	3	4	5	6	7	8	9	10	12	13	14	15	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
TOTAL LIVING POPULATION NOVEMBER, 1954	72	97	26	35	318	193	70	116	28	17	70	33	24	12	61	31	78	215	18	31	26	22	647	414	740	336	534	16	214	616	374	2608
Ammobaculites dilatatus	2	1			2	1										1		1			1				1	6		1	11	12		
salsus & vars	7				8	13	1	1	1	1	4	3	1		6	4	8	3	5	1	1	3	64	97	12	15	2		20	120	66	1600
spp.																										17	2	1	4	2	2	
Ammoscalaria pseudospiralis			1		2		1		2				1	1		2	1	3		5	2	10	7		103	21	79		17	1		
Bolivina lowmani		1				3						1											2		2							
striatula	2	3		1	4	6	2	1			3	1	2		4	1	1	2	2				12	2	10	5	6	1	4	2	2	
Buliminella elegantissima		1			1	1					1							1		1		1			1							
Elphidium delicatulum																							9	6	1	2	3		2	1	1	2
discoidale		4	1					1																								
galvestonense			1																													
gunteri	6	6	4		42	8		10	2	1	2	3	1	1	3	1	1	4		1	1	1	12	4	9	4	91	2	6	10	7	114
incertum mexicanum			1		7	3	1	1							1											1						
cf koeboeense												1						1					19		1		1					
matagordanum	1	1			4	1		1	2				1					48					140	8		1			7	4		
poeyanum	2			1	7	3	1	2	1	3		2	1		1	1	4	8	2				9	3	4		3	1		7	2	
spp.	2				4												2						1									
Entosolenia sp.					1																				1			1		1		
Eponidella gardenislandensis		1			2			2															4	17		1				66	23	154
Massilina peruviana																																
protea											1										1											
sp.																																
Miliammina fusca																					1											46
sp.	1						1																		1							
Nonionella atlantica		5	1																													
Quinqueloculina cultrata	1	1									2			1	1		1						2	1	2	1			29	4	3	
funafutiensis	1	7	3	3							29	5	4	1		2				2	1						2					
lamarckiana	2	11		3			2				9	4	2							8	3				4							
poeyana	11	20	2	2					2						4					4	9	1		1	2	1				11	4	
rhodiensis	4	2					3																									
seminulum		8	1	2						1	12			4	1					1	4	1			6							
wiesneri	1	1																														
spp.	3	3		1																								2	3		2	
Reophax nana	1					1		1							2																	
Rosalina floridana	2						5																									
Streblus beccarii var. A	14	16	10	15	90	74	18	76	16	11	6	11	11	3	31	17	49	121	9	7	1	4	338	268	566	248	335	7	99	330	228	700
beccarii var. B	2	4	1	7	143	80	23	20	2			2			3	2	10	23				1	26	7	11	12	7		4		6	2
Triloculina sidebottomi	4	1					7				1			1	4					1	1		1		1	1	3		8	41	28	88
Other spp.	3						5											1					1		2					4		2

TABLE 6. Distribution of living Foraminifera in surface sediment samples during November, 1954.

STATION	1	2	3	4	5	6	7	8	9	10	12	13	14	15	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
TOTAL LIVING POPULATION JANUARY, 1955	110	166	78	83	391	104	125	44	19	3	85	79	53	20	265	19	160	134	9	30	7	18	239	1436	101	128	228	19	66	1050	491	2572
Ammobaculites dilatatus																										4	15		2	6		
salsus & vars	1				6	7			1			3			37		4	7	3				48	968	12	1	1	1	5	369	73	166
spp																										2	1		1	6		
Ammoscalaria pseudospiralis	7	1	1	4					3		3	2	1	2	24	3	43	8		1	4	4	7		7	12	20		2			
Bolivina lowmani																																
striatula	1	4		1	2	2	4	1							4		2	3			1		4	12	2	5	9	1	1	9		
Buliminella elegantissima		3				1	1								1																	
Elphidium delicatulum															7								5	20		1			4		2	8
discoidale	1	1															1															
galvestonense																																
gunteri	6	2	16	2	161	1	5	4	2		1	1	1	5	64	1	4	5		1		1	6	52	8	26	87	4	25	51	15	52
incertum mexicanum																																
cf koeboeense			2												2		2						6		2	1						
matagordanum	1		1			2									41	1	7	9				1	35	12	2	9	2	1		126	58	48
poeyanum	3	13		24	51	12	23	1	1	1	3		3		2	5	12	27				3	1	36	11	8	2	3	11	72	14	
spp.																																
Entosolenia sp.					1										7								5	4		3	3			6	1	
Eponidella gardenislandensis					3	1									1		1	1					5	16	2					18	14	172
Massilina peruviana	3																															
protea																																
sp.	4										1															1						
Miliammina fusca																														45	10	20
sp.															1			1														
Nonionella atlantica																																
Quinqueloculina cultrata	2	8							1	1	3	1	1	1	5			2								1	5	2				
funafutiensis	6	7	5	8							29	45	20	4					1	2		1			2		2		1			
lamarckiana	8	8	5								7	9	7				3								1							
poeyana	5	18	35	6							1				2						2	1	1		1		7			12		
rhodiensis	11			1																												
seminulum	6	2	10								4	2		1	3		2	1														
wiesneri	1	1																														
spp.	1			1	3						1	3	3		6					2					2	1			1	3	3	8
Reophax nana					1										2																	4
Rosalina floridana	1																															
Streblus beccarii var. A	25	87	3	32	150	65	78	36	11	1	28	13	17	7	39	9	70	67	5	23		6	114	312	38	50	61	7	10	369	292	592
beccarii var. B		10		4	13	12	14	1			4				2		9	3		1			2	4	8		10		1	9	7	
Triloculina sidebottomi	17	1						1							6										2	3	3		2	9	2	8
Other spp.						1									9							1			1							

TABLE 7. Distribution of living Foraminifera in surface sediment samples during January, 1955.

STATION	1	2	3	4	5	6	8	9	10	12	13	14	15	17	18	19	20	21	22	23	24
TOTAL LIVING POPULATION MARCH, 1955	116	78	72	25	39	28	50	22	5	48	54	143	19	331	45	183	41	10	17	16	14
Ammobaculites dilatatus				1								1									
salsus & vars.	1				3	2			1		3			36	4	3	3				
spp.																					
Ammoscalaria pseudospiralis	9	2		4				2	3			1	2	7	9	32	1	2			1
Bolivina lowmani																					
striatula	1	2			1					1	2	1		8		1		1			
Buliminella elegantissima		1								2	1			2							
Elphidium delicatulum	3													15	2	7	4				
discoidale																					
galvestonense			1																		
gunteri	4	4	10	1	3	14	7	1				1	4	61	3	4	2			1	
incertum mexicanum		8	3																		
cf. koeboeense														1							
matagordanum	4	2												6	1	2	6				
poeyanum	9	3		12	8	3	6	4		3	1	99	5	117	8	28	2				4
spp.														7		1					
Entosolenia sp.								1						4							
Eponidella gardenislandensis					1		2							1		1	2				
Massilina peruviana		1																			
protea																					
sp.	1	1											1					1			
Miliammina fusca																					
sp.																					
Nonionella atlantica																					
Quinqueloculina cultrata	1												1	2							
funafutiensis	10	5	4	1						38	36	23	4		1	1			10	6	1
lamarckiana	3	2																			
poeyana	6	9	44	1										1					2	2	
rhodiensis	11		1																		
seminulum	2	5	6							2											
wiesneri		2																			
spp.	3	2												2						1	
Reophax nana	1																				
Rosalina floridana	8																				
Streblus beccarii var. A	22	3	2	3	21	7	22	14	1	1	10	10		32	13	86	21	4	5	5	7
beccarii var. B	7	4		2	2	2	13			1	1	7	2	2	4	16		2		1	
Triloculina sidebottomi	4	22	1											27		1					1
Other spp.	6																				

TABLE 8. Distribution of living Foraminifera in surface sediment samples during March, 1955.

STATION	1	2	3	4	5	6	7	8	9	10	12	13	14	15	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
TOTAL LIVING POPULATION MAY, 1955	109	149	12	47	292	102	157	156	9	32	33	82	139	38	45	57	139	149	9	73	432	25	370	165	151	113	372	158	92	248	84	653
Ammobaculites dilatatus	1									1								1					1		1	1						
salsus & vars			1		13	32	1	3			1	1			3	1	16	26					113	17	1	13		10	19	39	28	390
spp																							1									
Ammoscalaria pseudospiralis	21	4	1	8		1	10	5		9		3	13	1	2	12	16	15	1	18	2	2	4		20	2	66		3			
Bolivina lowmani							1											1										1				
striatula	3			1	1			1		2	1	5	2	2			1	4		5		1	2	1	2		10	2				
Buliminella elegantissima	8						1					1	1	1				2							1							
Elphidium delicatulum					5	1	2			1					4	2	2	1			6		21	15	1			10	2	1		19
discoidale																																
galvestonense																																
gunteri	4	1	1	2	71	1	8	16				2			17	1		1	1		3				4		24	3	1	3	2	2
incertum mexicanum		1																														
cf koeboeense													1								1		7									
matagordanum	2				2	11		5		6					4	2	1	6				1	31	2	2	6		7		66	1	5
poeyanum	2	4		10	10	1	21	6	1		2		12	4	1	5	3	11		1	9	4	4	3	13	15	28	3	5			1
spp					2																				1	3	1					
Entosolenia sp.					1																			1			1					
Eponidella gardenislandensis					6			2										2					3	6						49	23	75
Massilina peruviana										1		1																				
protea	1																															
sp.	1			1																1												
Miliammina fusca																																1
sp.										1								1				2										
Nonionella atlantica							1																									
Quinqueloculina cultrata	1					1						1		2	1	1					2	1										
funafutiensis	14	65	2	7	1	2	4		1	3	20	51	79	13			1		1	6	4	3			7							
lamarckiana					1																											
poeyana	6	49	2	2							1	1	12	3		1				1	380		1		1		1					
rhodiensis	4	3		1							1																					
seminulum		6											3												3		1					
wiesneri																																
spp.		5		2						2	2		1	2		1					5				1							
Reophax nana	1																															
Rosalina floridana	1						8			3																						
Streblus beccarii var. A	14	7	3	7	115	37	43	90	7	2	5	13	12	9	11	18	90	67	5	32	2	8	166	116	56	60	111	111	60	88	28	158
beccarii var. B	18	3	2	4	62	15	52	26				2	3	1	2	9	7	3	1	8	2	3	8	1	23	11	14		1	2	2	2
Triloculina sidebottomi	7	1		2	2		1	2				1				4	2	8		1	12		7	3	14	2	115	11	1			
Other spp.							4			1											4		1									

TABLE 9. Distribution of living Foraminifera in surface sediment samples during May, 1955.

STATION	1	2	3	4	5	6	7	8	9	10	12	13	14	15	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
TOTAL LIVING POPULATION JUNE, 1955	20	182	39	53	165	87	36	160	24	42	67	41	33	20	81	89	110	66	7	19	6	22	864	720	165	65	102	368	25	177	63	320
Ammobaculites dilatatus			1			1	1	1			1												2	1		2	1					
salsus & vars.		2			16	11	1	1				1	2	3	1	3	8	3					431	53	6	4		19	9	62	21	202
spp.																																
Ammoscalaria pseudospiralis		3	1	7				7	3	11	3	8	4	5	11	13	29	4	2	9	3	8		1	31		7	1				
Bolivina lowmani										1					1		1						2		1		1					
striatula	1	1		6	3		1			4	3	1				7		1		2			4	1	4		2	19	2			
Buliminella elegantissima		2		1		1							1	1	1					1			1									
Elphidium delicatulum					4	1	1	3			1				1	2		2					19	36			3	3		1		5
discoidale																																
galvestonense			1					1																								
gunteri		1		1	15	5	1	40						1	15	1		1	1			1	2	3	11	2	2	12	1	4	3	2
incertum mexicanum																																
cf. koeboeense																							26		1		1					
matagordanum	1	1			4			1	2	2					7	1		11					133	5		13		58		40	2	1
poeyanum				1	2	1	4	7		1			3		2	7	6			1			2	10	4	2	3	10	3			
spp.					3																			2				1				
Entosolenia sp.					1										1	1												4				
Eponidella gardenislandensis					1			1								1							14	15				1		8	17	42
Massilina peruviana																																
protea																																
sp.				3						2												2										
Miliammina fusca																											1					
sp.																																
Nonionella atlantica		3																														
Quinqueloculina cultrata		10						1		1			2							1						1	1	2				
funafutiensis	2	3	2	3						4	20	15	2			4	3		1	2	1	1			4			3				
lamarckiana																																
poeyana	8	144	23	8				1			14		3	1		3				1						1		3				
rhodiensis	1																															
seminulum		9	1	1						4	1														1							
wiesneri																																
spp.			1	1							3				1							1						1				
Reophax nana																																
Rosalina floridana	2			1																			1									
Streblus beccarii var. A		2	4	14	80	39	24	60	17	9	14	10	14	7	18	31	59	42	2	2	1	8	202	567	79	30	43	127	9	50	19	66
beccarii var. B		1	2	4	36	28	2	35	2	2	6	4	1	2	20	13	4	2	1		1	1	22	25	23	9	29	38	1	12		1
Triloculina sidebottomi	3		3	1			1	1		1	1	1	1		2	2							3	1		1	8	61				
Other spp.	2			1								1																5			1	1

TABLE 10. Distribution of living Foraminifera in surface sediment samples during June, 1955.

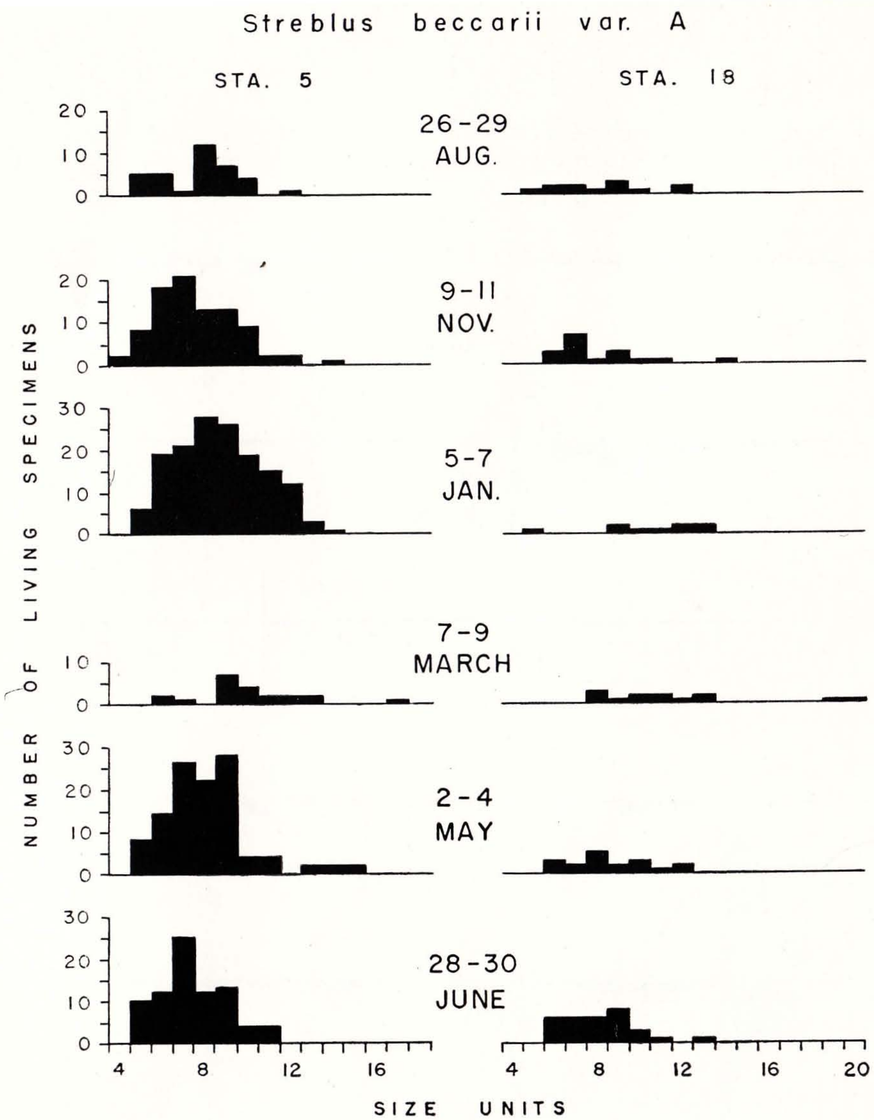

FIGURE 2. Size distribution histograms of living *Streblus beccarii* var. A at stations 5 and 18. Size divisions are 0.025 mm.

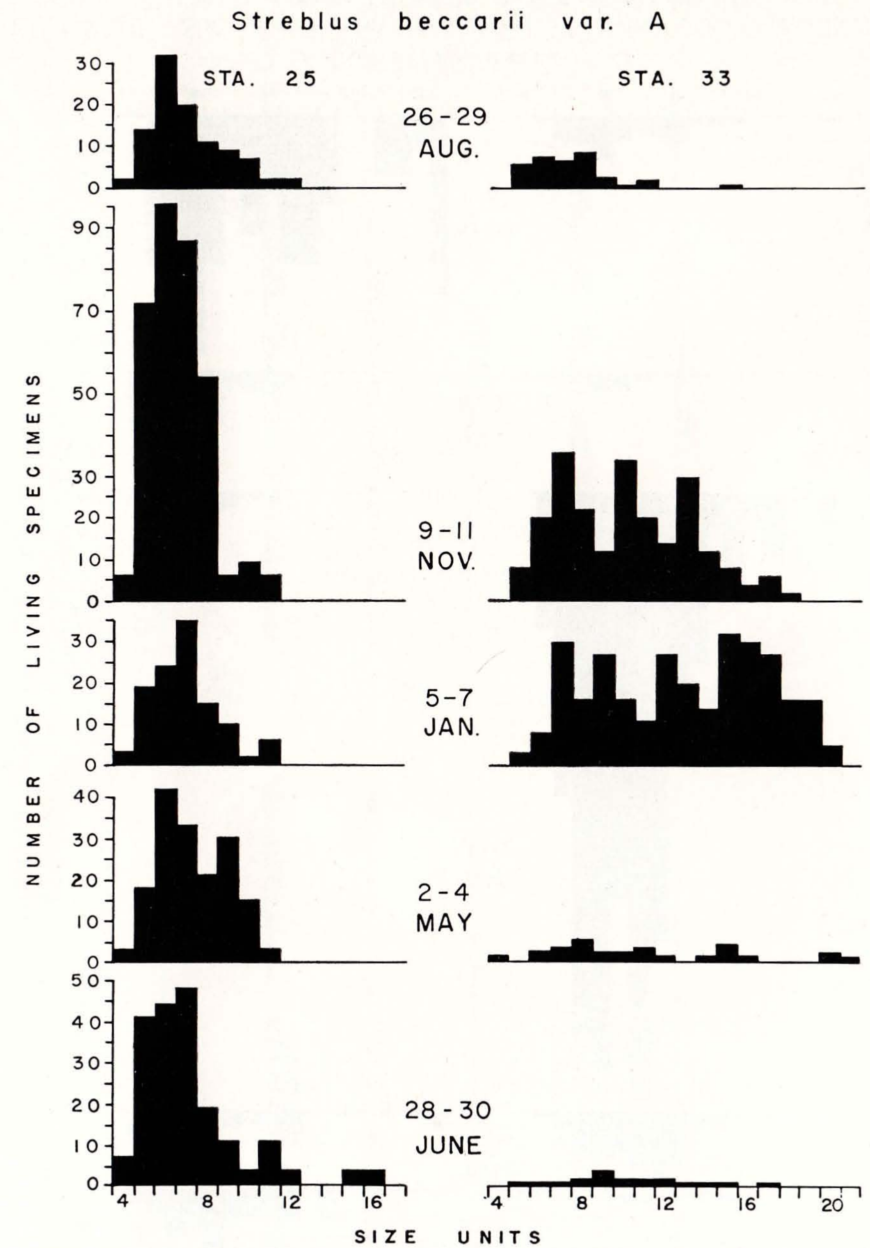

FIGURE 3. Size distribution histograms of living *Streblus beccarii* var. A at stations 25 and 33. Size divisions are 0.025 mm.

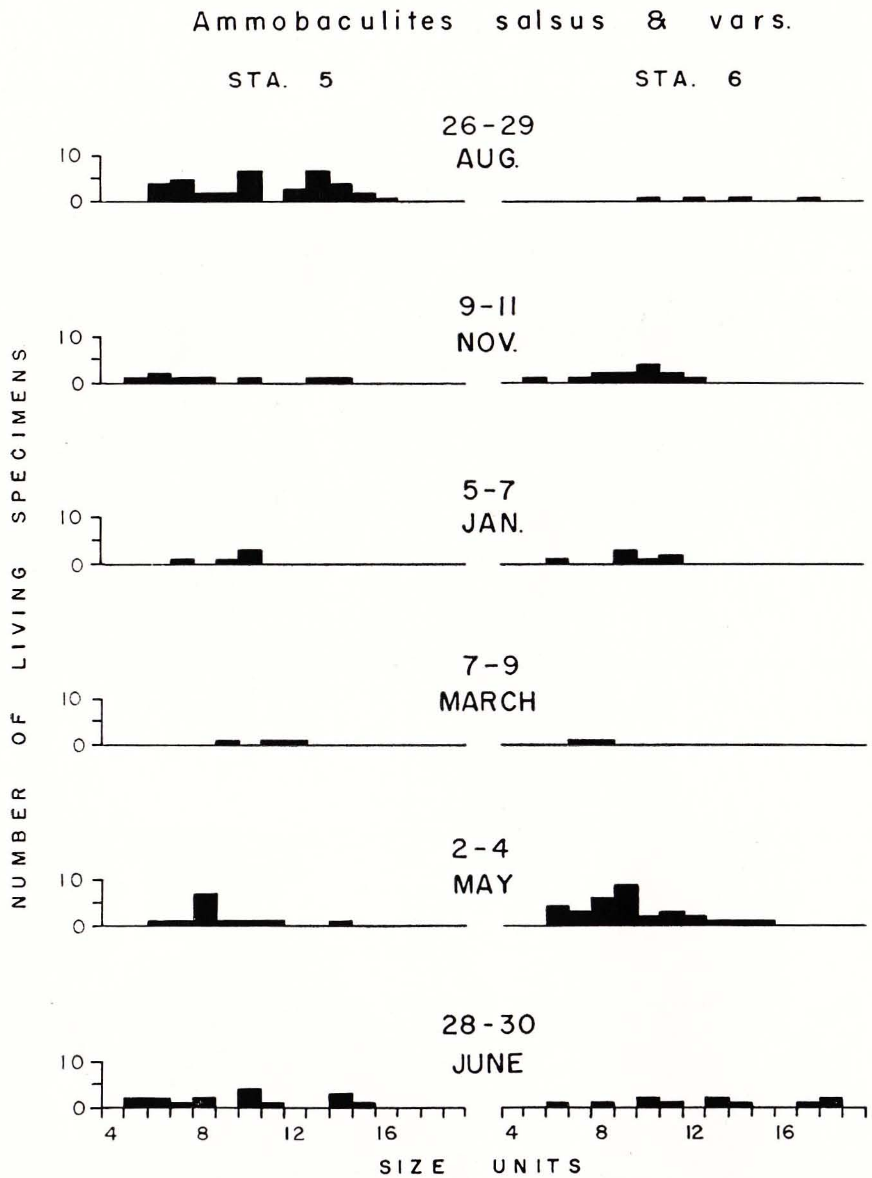

FIGURE 4. Size distribution histograms of living *Ammobaculites salsus* and vars. at stations 5 and 6. Size divisions are 0.025 mm.

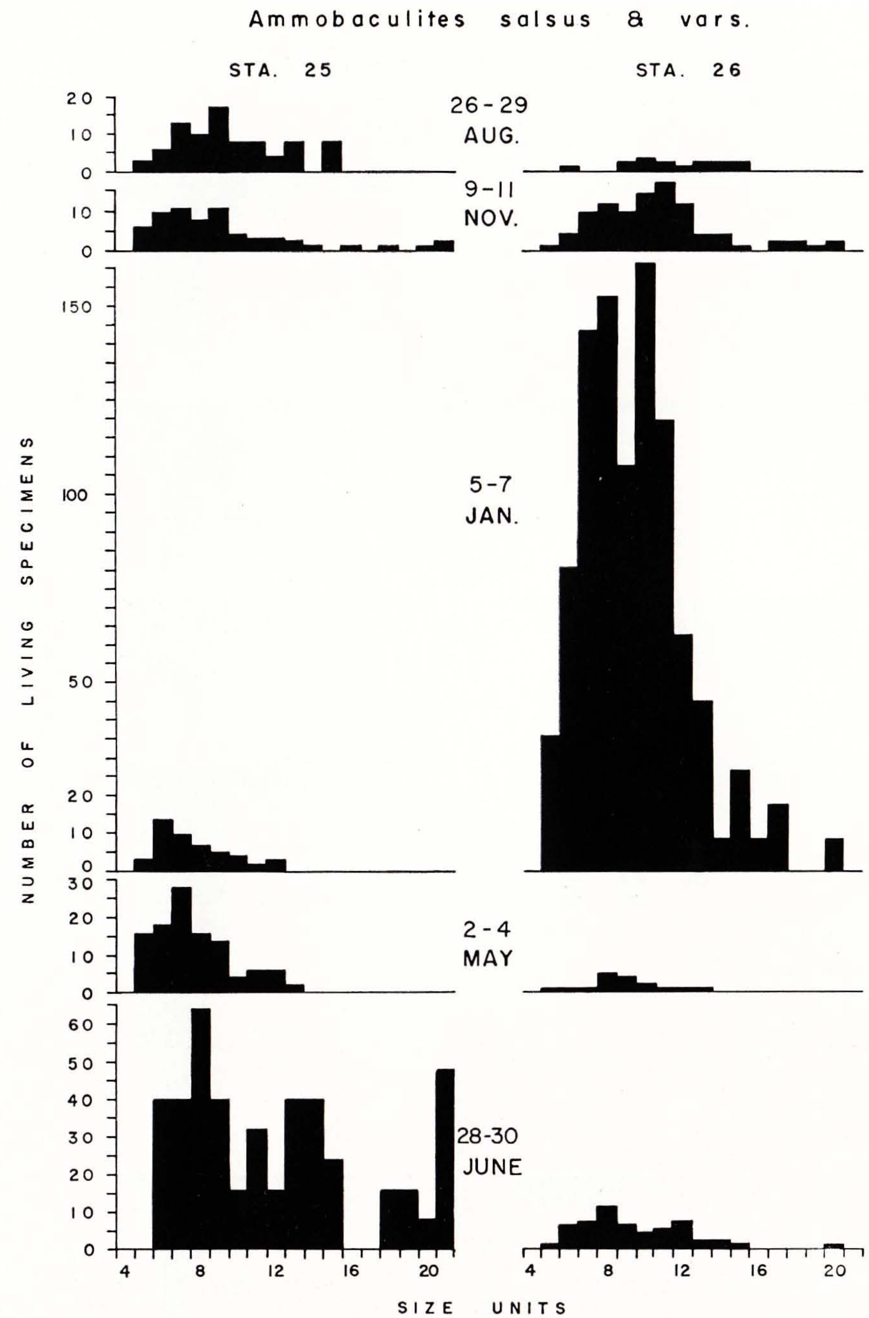

FIGURE 5. Size distribution histograms of living *Ammobaculites salsus* and vars. at stations 25 and 26. Size divisions are 0.025 mm.

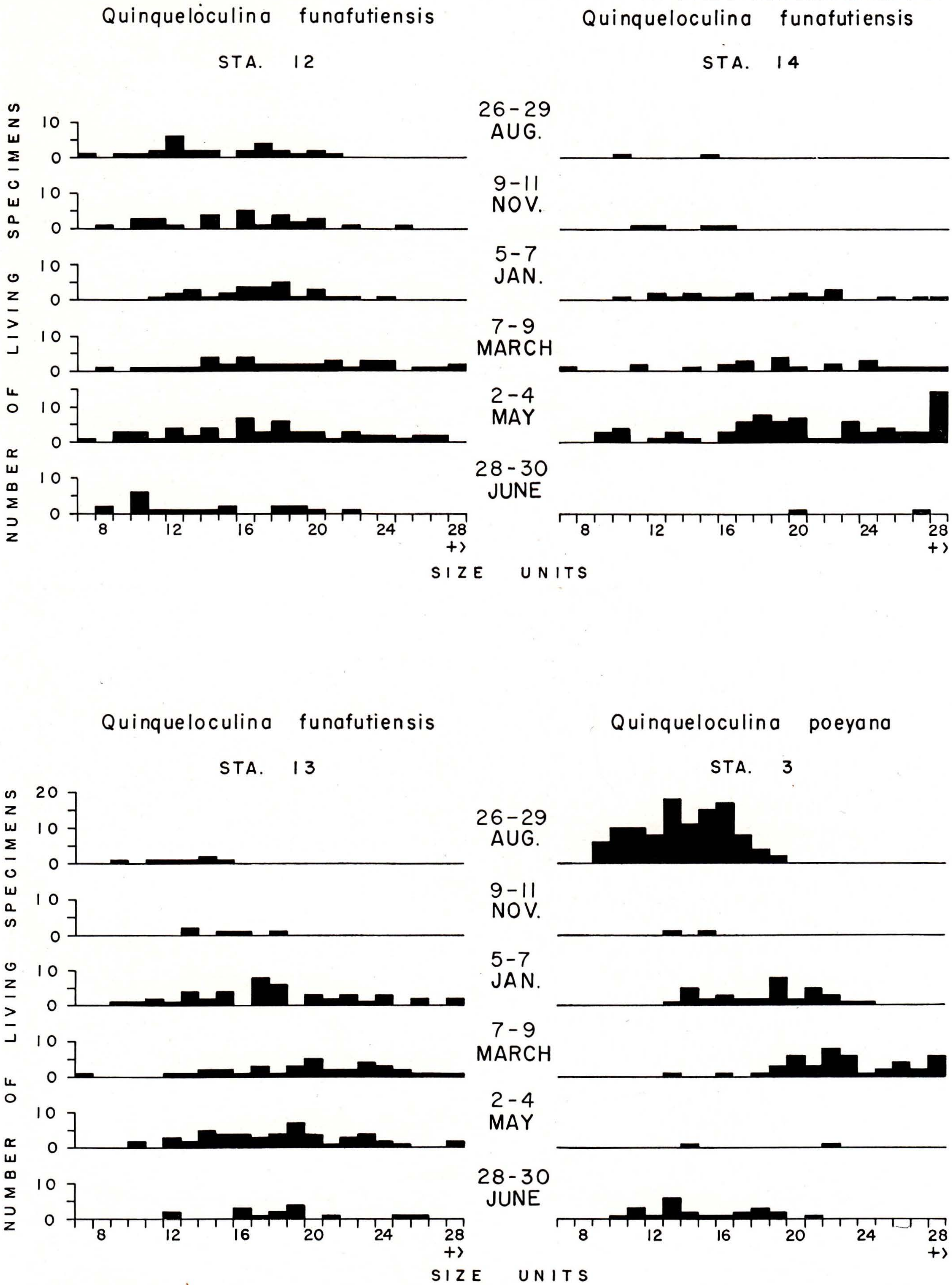

FIGURE 6. Size distribution histograms of living *Quinqueloculina funafutiensis* and *Quinqueloculina poeyana* at stations 3, 12, 13, and 14. Size divisions are 0.025 mm.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME VIII, PART 3, JULY, 1957

172. RESTUDY OF SOME CUBAN LARGER FORAMINIFERA

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ABSTRACT

Topotypes of **Operculinoides bermudezi** (D. K. Palmer) from near Madruga, Habana Province, Cuba, are evaluated to demonstrate the variability that can occur in a species of camerinid, and specimens assigned to this same species or supposedly closely related species from other areas are compared with the topotypes. Most of these closely related species fall within the specific limits demonstrated for **Operculinoides bermudezi.**

Four species of discocyclinids, **Discocyclina (Discocyclina) barkeri** Vaughan and Cole, **D. (D.) cristensis** (Vaughan), **D. (D.) mestieri** Vaughan, and **Pseudophragmina (Athecocyclina) stephensoni** (Vaughan), which were found associated wth the topotypes of **Operculinoides bermudezi** are discussed and illustrated.

INTRODUCTION

During the initial studies of many of the larger Foraminifera of the Caribbean region specific names were proposed without adequate analysis of large suites of specimens. The failure of authors to understand the inherent individual variability between specimens of a single population has led to a proliferation of specific names for specimens which can be demonstrated to have the same fundamental characters. Cole (1953) has demonstrated that many species of *Lepidocyclina* are extremely variable and he (1953a, p. 37) briefly discussed this same problem in connection with *Operculinoides bermudezi* (D. K. Palmer). However, as he believed his analysis of this species was incomplete, he suggested that *O. bermudezi* and other named, but obviously closely related species, should be restudied.

The late D. W. Gravell had sent Cole a large sample from the type locality of *Operculina bermudezi* D. K. Palmer (1934, p. 238). This sample came from the south side of a cut on the Central Highway 2 km. west of Madruga and about 100 meters east of the Cane line railroad overpass to Central San Antonio, Habana Province, Cuba (= D. K. Palmer's sta. 757). Over 200 specimens of *O. bermudezi* were separated from this sample and they are the basis of this study.

The sample contained in addition four species of discocyclinids: *Discocyclina* (*Discocyclina*) *barkeri* Vaughan and Cole (1941, p. 57), *D.* (*D.*) *cristensis* (Vaughan) (1924, p. 814), *D.* (*D.*) *mestieri* Vaughan (1945, p. 37), and *Pseudophragmina* (*Athecocyclina*) *stephensoni* (Vaughan) (1929, p. 16) besides such obviously reworked Cretaceous species as *Orbitoides palmeri* Gravell and *Vaughanina cubensis* D. K. Palmer. These Paleocene discocyclinids were restudied.

Although the principal result of this study was the determination that numerous closely related Caribbean species of camerinids erected by de Cizancourt (1948, 1951) and others fall within the specific limits of *O. bermudezi,* it was found that the genus *Bontourina* Caudri (1948, p. 477) is synonymous with *Discocyclina* s.s.

A tabulation of the reported geographic and stratigraphic occurrence in the Caribbean area of the 5 species of larger Foraminifera discussed in this article is given in Table 1.

TABLE 1. Reported Geographic and Stratigraphic Occurrence of Species Discussed in This Paper

	Operculinoides bermudezi	Discocyclina (Discocyclina) barkeri	Discocyclina (Discocyclina) cristensis	Discocyclina (Discocyclina) mestieri	Pseudophragmina (Athecocyclina) stephensoni
Barbados	1, 2, 3*	1		1	
Cuba	1	1, 2, 3*	1	1, 2	1
Georgia	1				1
Haiti	1, 2				
Mexico			1, 2		
Trinidad	1, 2	1, 2			
Venezuela	1, 2	1, 2	1, 2	1, 2	1

1 — Paleocene; 2 — lower Eocene; 3 — middle Eocene.
* Possibly reworked.

The writer wishes to express his sincere thanks to Dr. W. Storrs Cole of Cornell University for supplying the material used in this study and for his many helpful suggestions and criticisms throughout the progress of this work. The cost of the plates has been contributed by the William F. E. Gurley Fund for Paleontological Research at Cornell University. The specimens are deposited in the Cole collection at Cornell University and will be presented eventually to the U. S. National Museum.

SYSTEMATIC PALEONTOLOGY

Family CAMERINIDAE

Genus **Operculinoides** Hanzawa, 1935

Operculinoides bermudezi (D. K. Palmer)

Plate 14, figures 1-27

1934. *Operculina bermudezi* D. K. PALMER, Mem. Soc. Cubana Hist. Nat., vol. 8, pp. 238-240, pl. 12, figs. 3, 6-9.
1937. *Pellatispirella antillea* HANZAWA, Journ. Paleont., vol. 11, p. 116, pl. 20, figs. 8-10; pl. 21, fig. 1.
1939. *Camerina pellatispiroides* BARKER, U. S. Nat. Mus., Proc., vol. 86, no. 3052, pp. 325, 326, pl. 20, fig. 10; pl. 22, fig. 4.
1941. *Miscellanea antillea* (HANZAWA). VAUGHAN and COLE, Geol. Soc. Amer., Sp. Paper 30, pp. 33-35, pl. 4, figs. 1-4; pl. 6, figs. 3, 3a.
1941. *Miscellanea tobleri* VAUGHAN and COLE, idem, pp. 35, 36, pl. 4, figs. 5-7; pl. 7, fig. 1.
1941. *Miscellanea soldadensis* VAUGHAN and COLE, idem, p. 36, pl. 4, figs. 8, 9 (not *Operculinoides soldadensis* VAUGHAN and COLE, 1941, idem, pp. 40, 41, pl. 9, figs. 5-8; pl. 10, figs. 1, 2).
1944. *Ranikothalia antillea* (HANZAWA). CAUDRI, Bull. Amer. Paleont., vol. 28, no. 114, pp. 372, 373, pl. 30, figs. 4, 5; pl. 32, fig. 15; pl. 33, fig. 21; pl. 34, figs. 23, 25.
1945. *Miscellanea antillea* (HANZAWA). VAUGHAN, Geol. Soc. Amer., Mem. 9, pp. 27-29, pl. 3, figs. 1-10; pl. 4, fig. 1.
1945. *Miscellanea soldadensis* VAUGHAN and COLE. VAUGHAN, idem, pp. 30, 31, pl. 5, figs. 2-5.
1947. *Miscellanea antillea* (HANZAWA). COLE and BERMUDEZ, Bull. Amer. Paleont., vol. 31, no. 125, pp. 195, 196, pl. 15, figs. 10, 11.
1948. *Nummulites (Nummulites) senni* DE CIZANCOURT, Soc. Géol. France, Mém. 57, vol. 27, n. ser., pp. 19, 20, pl. 1, figs. 13-17.
1948. *Nummulites (Nummulites) convexa* DE CIZANCOURT, idem, p. 21, pl. 1, fig. 19; pl. 2, figs. 8-13.
1948. *Nummulites (Nummulites) barbadica* DE CIZANCOURT, idem, pp. 21, 22, pl. 1, fig. 18; pl. 2, figs. 5-7.
1948. *Nummulites (Nummulites) scotlandica* DE CIZANCOURT, idem, pp. 22, 23, pl. 2, figs. 1-3.
1948. *Nummulites (Nummulites) aster* DE CIZANCOURT, idem, p. 23, pl. 1, figs. 10-12.
1948. *Nummulites (Nummulites) pellatispiroides* (BARKER). DE CIZANCOURT, idem, pp. 24, 25, pl. 2, figs. 14-16.
1948. *Nummulites (Operculinoides) catenula* (CUSHMAN and JARVIS). DE CIZANCOURT, idem, pp. 25-27, pl. 2, figs. 17-24.
1948. *Nummulites (Operculinoides) bermudezi* (D. K. PALMER). DE CIZANCOURT, idem, pp. 27-29, pl. 1, figs. 1-5.
1948. *Nummulites (Operculinoides) torifera* DE CIZANCOURT, idem, p. 29, pl. 1, figs. 6-8.
1950. *Nummulites (Nummulites) caraibensis* DE CIZANCOURT. in THALMANN, 1950, Contr. Cushman Found. Foram. Res., vol. 1, no. 6, p. 43.
1951. *Nummulites (Nummulites) sanctijoanni* DE CIZANCOURT, Soc. Géol. France, Mém. 64, vol. 30, n. ser., p. 48, pl. 4, figs. 8, 9.
1951. *Nummulites (Nummulites) henrici* DE CIZANCOURT, idem, pp. 48, 49, pl. 4, figs. 1-3.
1951. *Nummulites (Nummulites) senni* DE CIZANCOURT, idem, p. 49, pl. 4, fig. 6.
1953. *Operculinoides bermudezi* (D. K. PALMER). COLE, Bull. Amer. Paleont., vol. 35, no. 147, pp. 35-37, pl. 1, figs. 5-7; pl. 3, figs. 2-12.
1953. *Operculinoides georgianus* COLE and HERRICK, Bull. Amer. Paleont., vol. 35, no. 148, pp. 52-54, pl. 4, figs. 1-21; pl. 5, figs. 1-3.

Megalospheric generation.—Test involute lenticular, from 1 to 3 mm. in diameter with a diameter/thickness ratio of 1.6 to 2.8. Normally, the more compressed individuals have the greater diameter. The periphery is bluntly rounded and occasionally somewhat inflated. The center of the test is marked by an elevated boss which in weathered specimens appears to be made of a cluster of knobs which surround a larger central mass. Straight or slightly recurved sutures, which are sometimes beaded in weathered specimens, radiate from the umbonal cluster to the periphery. The surface between the sutures is smooth and finely perforate.

Median sections show 1¾ to 3½ whorls with a total of 22 to 55 chambers in all volutions and 10 to 30 chambers in the final volution. The chambers of the final whorl are higher than wide. The spiral wall is double, composed of a thick outer wall pierced by coarse radial canals, and a thin, denser inner wall. These walls are separated by a spiral canal approximately 5μ in diameter. The septa are straight or slightly recurved with double walls resulting from an infolding and prolongation of the inner shell layer (Pl. 14, figs. 24, 27). As a result of this infolding, the spiral canal is bent inward with the inner shell layer to form a radial extension 5 to 10μ in diameter running down the middle of each septum. The inner wall lines the entire chamber except in the zone of the marginal cord where the proximal chamber wall is formed by the outer margin of the preceding spiral wall. At this point, the infolding and prolongation of the inner layer forming the septa falls short of the base of the chamber by approximately 40μ, thus forming the slitlike aperture directly above the marginal cord.

The embryonic apparatus is bilocular, either with both chambers subspherical or with the second slightly compressed, separated by a straight or nearly straight wall. The dimensions of these chambers in several specimens are given in tables 2 and 3.

TABLE 2. Measurements from median sections of individuals of *Operculinoides bermudezi*

	Megalospheric (Plate 14)				Microspheric
Specimen	Fig. 24	Fig. 25	Fig. 26	—	—
Diameter (mm.)	2.7	1.8	1.95	2.25	4.0
Number of whorls	2.8	2.25	2.75	2.3	4
Diameter of initial chamber (μ)	190	240	220	200	—
Total diameter of embryonic apparatus (μ)	225	300	340	300	—
Number of chambers in initial volution	10	12	11	10	9
Number of chambers in final volution	27	20	23	—	21
Total number of chambers	54	36	50	—	63

Transverse sections show the regions on both sides of the embryonic apparatus to be occupied by axial plugs which are separated into wedge-shaped segments by a series of radiating canals. The peripheral marginal cord is generally well developed, and is composed of numerous radiating wedge-shaped masses separated by coarse canals which extend from the outer surface to a point approximately 3/4 of the distance to the inner surface. The development of the marginal cord appears to be dependent upon the size of the individual as larger specimens have better developed cords than do smaller ones. The wall of the test between the marginal cord and axial plug is pierced by numerous fine straight radiating canals which appear to open on both the exterior and interior surfaces of the wall.

Microspheric generation.—The test is compressed lenticular with a low subcentral boss. The margin is more inflated and more broadly rounded than in megalospheric specimens, reflecting the highly developed marginal cord in the outermost whorl. In some cases the development of this feature is such that its trace may be seen externally as it revolves around the margins of the inner whorls. Average dimensions of microspheric specimens are 3 to 5 mm. in diameter with a diameter/thickness ratio of 2 to 3.5. A maximum diameter of 12 mm. has been reported by Palmer (1934, p. 239).

In median section 3½ to 5 whorls are present with a total of 40 to 65 chambers in all volutions and 20 to 30 chambers in the final volution.

TABLE 3. Measurements from transverse sections of megalospheric individuals of *Operculinoides bermudezi*

	Plate 14							
Specimen	Fig. 13	Fig. 14	Fig. 15	Fig. 16	Fig. 17	Fig. 20	—	—
Diameter (mm.)	1.6	1.9	2.25	2.25	2.2	2.4	1.9	1.45
Thickness (mm.)	1.0	0.8	1.0	1.0	1.2	1.25	0.85	0.8
Diameter of initial chamber (μ)	240	250	225	—	250	250	190	150
Total diameter of embryonic apparatus (μ)	250	—	310	300	375	350	250	210
Width of pillars (mm.)	0.5	0.5	0.7	0.62	0.63	0.62	0.4	0.3

TABLE 4. Measurements from transverse sections of microspheric individuals of *Operculinoides bermudezi*

	Plate 14	
Specimen	Fig. 21	Fig. 22
Diameter (mm.)	4.75	2.8
Thickness (mm.)	1.5	1.0
Width of pillars	0.75	1.0

EXPLANATION OF PLATE 14

FIGS.		PAGE
1-27.	*Operculinoides bermudezi* (D. K. Palmer)	107

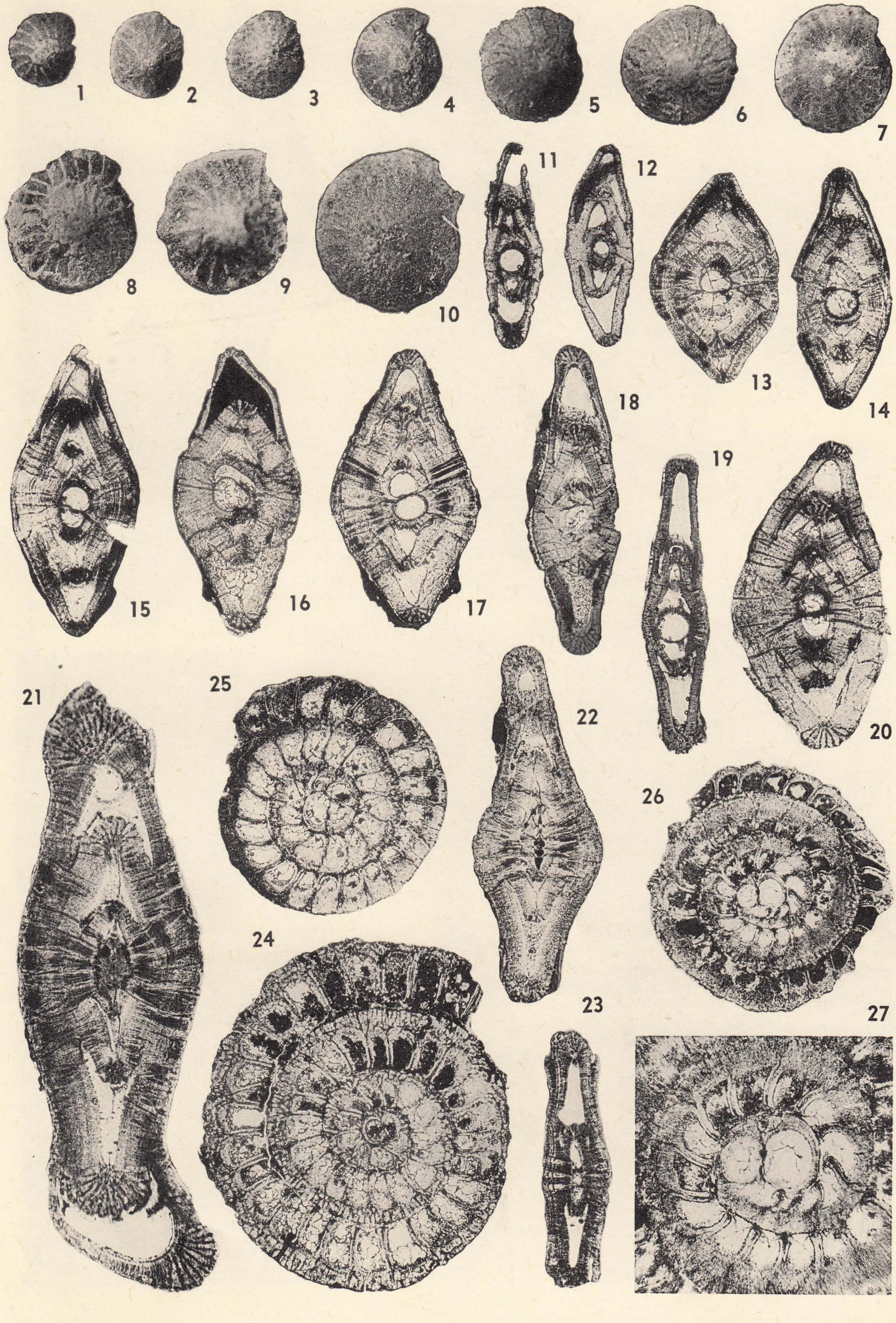
1-10. External views, ×10, to show variation in size and surface sculpture.

11-23. Transverse sections, ×20, to show the gradation from compressed individuals formerly called *O. georgianus* to lenticular individuals which were called *O. antillea;* 21, microspheric specimen; 11, 12, 19, 23 after Cole and Herrick (1953, pl. 4, figs. 12, 16, 18, 20).

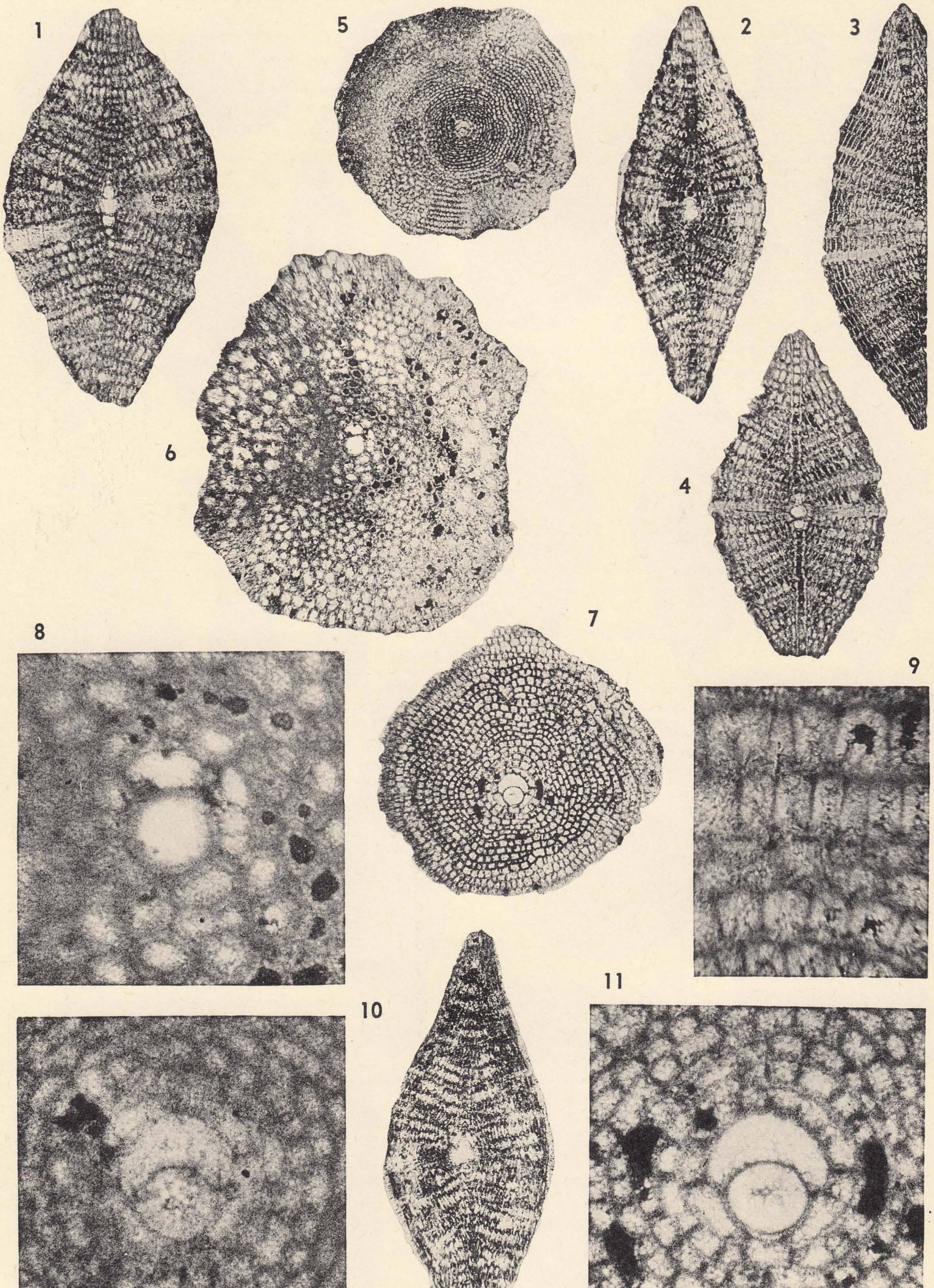
24-26. Median sections, ×20, of megalospheric specimens.

27. Part of a median section, ×40, illustrated as figure 26, to show the details of the embryonic chambers and the walls of chambers of the spire.

Unless otherwise stated all the specimens are from the late D. W. Gravell's re-collection of D. K. Palmer's station 757 whose locality description is given in the text.



Sachs: Cuban Larger Foraminifera



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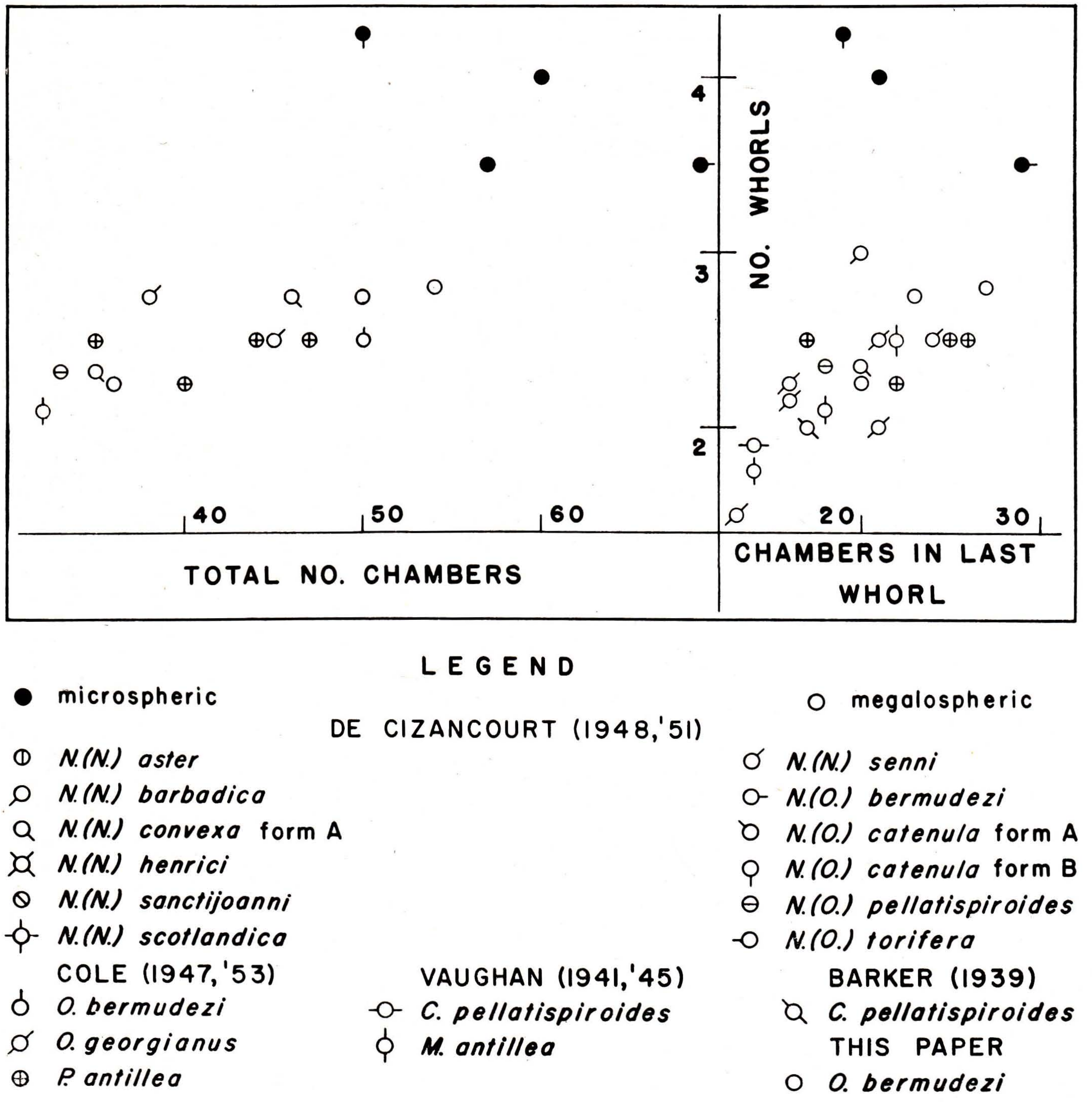


FIGURE 1. Scatter diagrams to show the relationship of species considered to represent *Operculinoides bermudezi* (D. K. Palmer).

EXPLANATION OF PLATE 15

Figs.		Page
1-12.	*Discocyclina* (*Discocyclina*) *barkeri* Vaughan and Cole	113

1-4, 12. Vertical sections, ×20.

5, 7. Equatorial sections, ×20; 7, topotype introduced for comparison; locality, Soldado Rock, Trinidad.

6. Slightly oblique equatorial section ×20, to show the variation in appearance of the equatorial chambers.

8-11. Parts of equatorial sections, 8, 10, 11, ×160; 9, ×230, to show the details of the embryonic apparatus and annular stolon; 8, illustrated by figure 6; 9, 10, illustrated by figure 5; 11, illustrated by figure 7.

Transverse sections show the highly developed marginal cord, composed of wedges of shell material separated by coarse radial canals opening on the exterior. These canals extend inward to a point approximately 1/6 of the distance from the inner margin of the spiral wall where they are met by numerous fine radial canals. These fine canals penetrate the entire thickness of the lateral wall in the region between the marginal cord and the axial plug in the same manner as in the megalospheric generation.

Remarks.—The generic classification of this species is not discussed as this has been adequately treated by Cole (1953a, pp. 28, 32-34). However, as he (1953a, p. 37) suggested, most authors have failed to

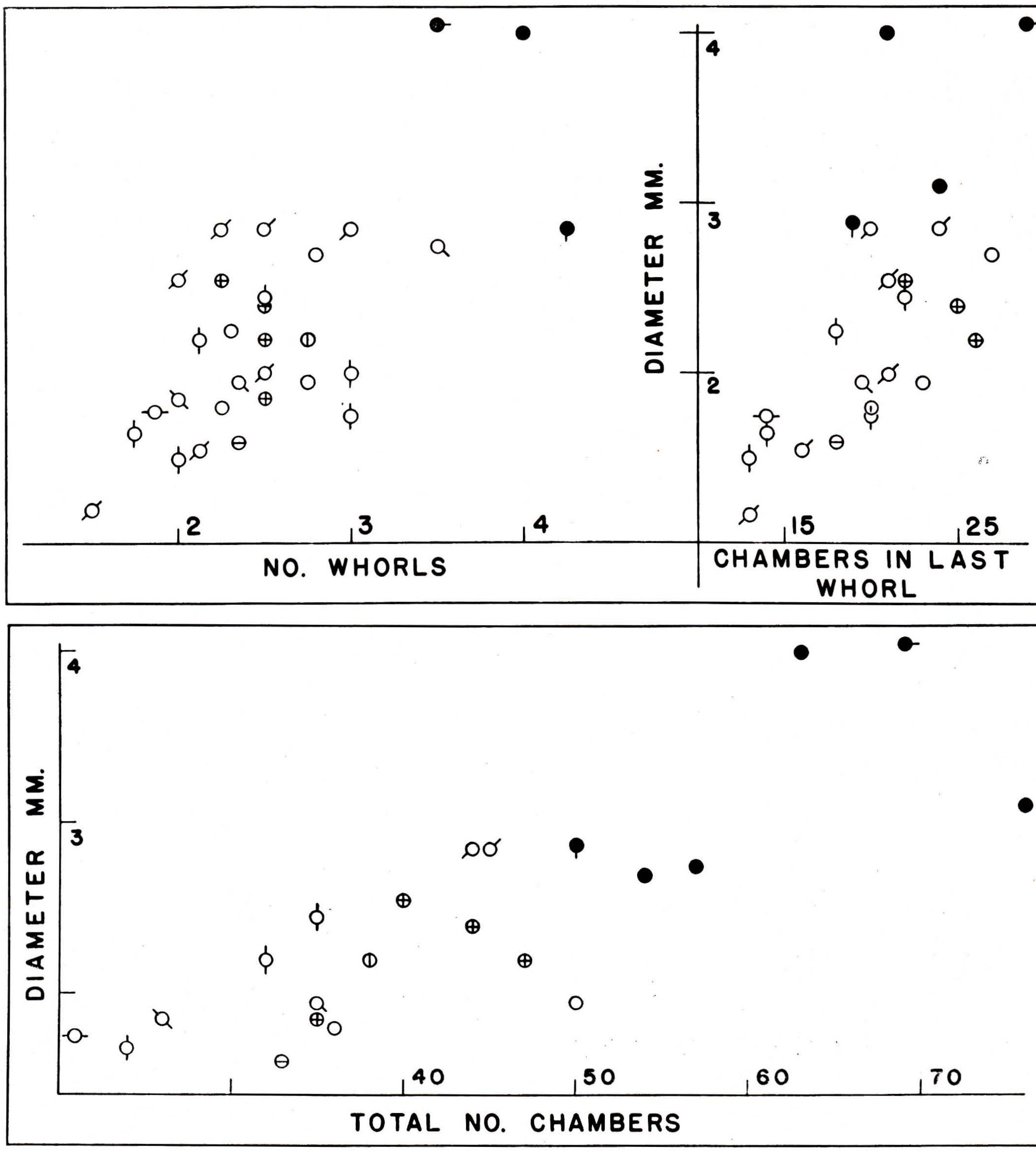


FIGURE 2. Scatter diagrams to show the relationship of species considered to represent *Operculinoides bermudezi* (D. K. Palmer). For explanation of symbols, see figure 1.

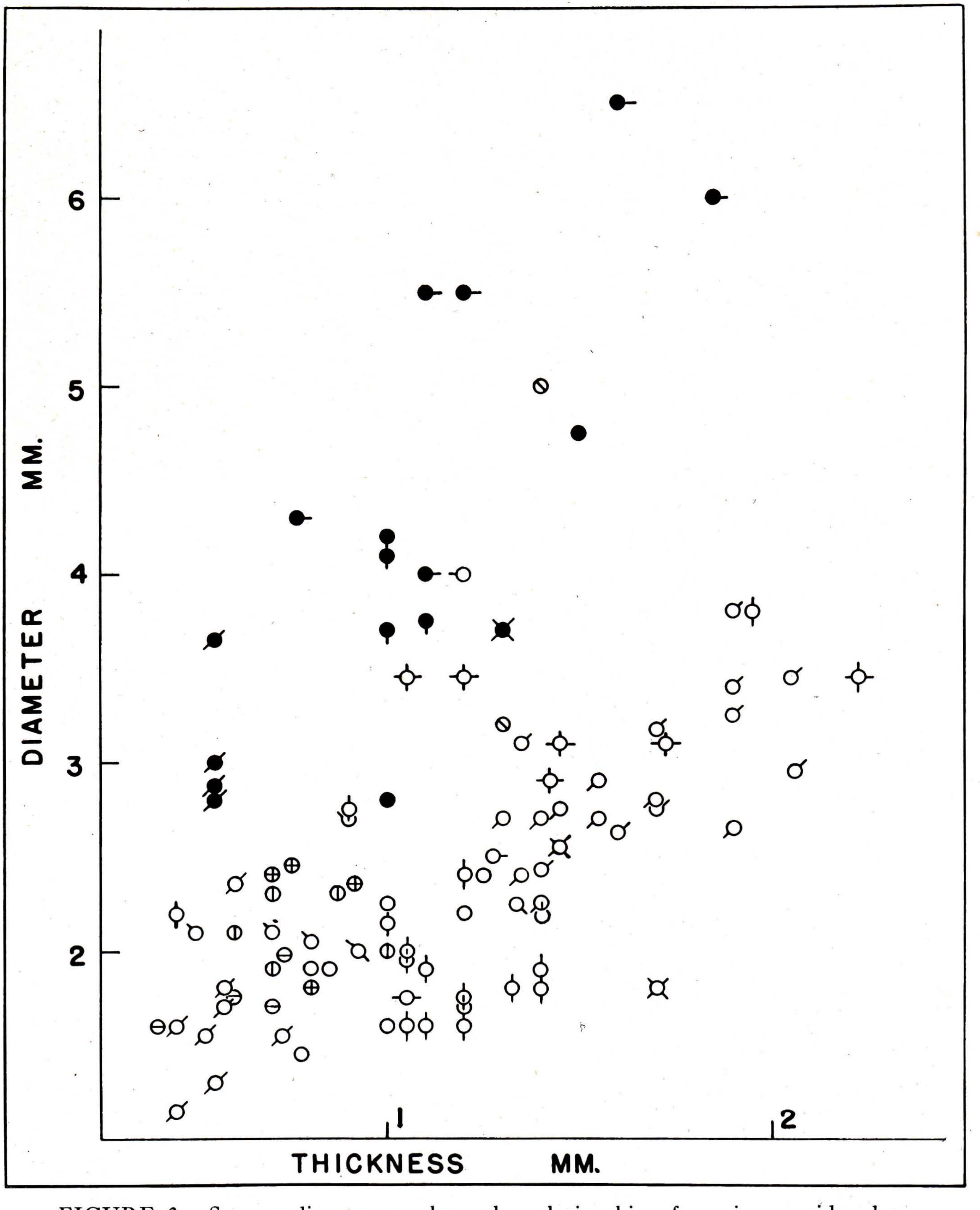


FIGURE 3. Scatter diagram to show the relationship of species considered to represent *Operculinoides bermudezi* (D. K. Palmer). For explanation of symbols, see figure 1.

realize the inherent individual variability of specimens of a single species in a given population, here represented by *Operculinoides bermudezi.*

As the numerous specimens available were studied, it became evident that this species is much more variable than previously thought. Many of the species erected for Paleocene representatives of this genus in the Caribbean area now appear to fall within the limits of a single species. If only a few specimens are available for study or if the end members of a series are compared, it is easy to separate them into distinct species; however, with increasingly abundant specimens this becomes more difficult until a point may be reached where a complete gradation is found from one end member to another.

Scatter diagrams (Figs. 1-3) were plotted from measurements of thin sections of selected specimens from the entire series of topotypes, to which have been subjoined measurements made from illustrations or given in tables by others for various species which are considered to be *O. bermudezi.* Among the species plotted on the diagrams are those listed by Cole (1953a, p. 35) in the synonymy of *O. bermudezi* and certain other species discussed in detail below.

Vaughan and Cole (1941, p. 36) erected the species *Miscellanea soldadensis* for a large camerinid with a well-developed marginal cord from Soldado Rock, Trinidad. Associated species were *Operculinoides antillea* (Hanzawa) and *Discocyclina* sp. The presence of a well-developed marginal cord and a rapidly expanding spire indicate that this is *Operculinoides* rather than *Miscellanea* (Cole, 1953a, p. 28). Comparison of their illustrations of this species with microspheric specimens of *O. bermudezi* shows that the two are identical.

Mrs. de Cizancourt (1948) described, among others, 6 new species of camerinids from the Paleocene and Eocene of Barbados. Comparison of her illustrations and descriptions of these with the suite of specimens from Cuba showed so many similarities that there is serious doubt as to the validity of the Barbadian species. Available measurements of these have been plotted on the scatter diagrams. From these it may be seen that there is a complete series with no grouping which could be considered of specific importance. The only differentiation that can be made is between microspheric and megalospheric forms. Moreover, it seems highly improbable that so many closely related species would be living side by side in the same environment at the same time.

In 1951 Mrs. de Cizancourt named 2 additional species, *Nummulites (Nummulites) henrici* and *N. (N.) sanctijoanni* from the Paleocene and lower Eocene of Venezuela. Again, there is no significant difference between these and the others as can be seen from the distribution of their measurements on the scatter diagrams. The close similarity of de Cizancourt's numerous species to *O. bermudezi* is further demonstrated by comparison of her figures with illustrations of *O. bermudezi* in this article as follows:

This article	De Cizancourt 1948	De Cizancourt 1951	
Pl. 14, fig. 1	Pl. 1, fig. 9	....	**Nummulites (N.) sp.**
Pl. 14, fig. 5	Pl. 2, fig. 4	Pl. 4, fig. 9	**Nummulites (N.) sanctijoanni**
Pl. 14, fig. 6	Pl. 2, fig. 14	....	**Nummulites (N.) pellatispiroides**
Pl. 14, fig. 8	....	Pl. 4, fig. 2	**Nummulites (N.) henrici**
Pl. 14, fig. 12	Pl. 2, fig. 17	....	**Nummulites (Operculinoides) catenula**
Pl. 14, fig. 13	....	Pl. 4, fig. 10	**Nummulites (N.) convexa**
Pl. 14, fig. 17	Pl. 1, fig. 13	....	**Nummulites (N.) senni**
Pl. 14, fig. 21	Pl. 2, fig. 24	....	**Nummulites (O.) catenula**
Pl. 14, fig. 22	....	Pl. 4, fig. 1	**Nummulites (N.) henrici**
Pl. 14, fig. 23	....	Pl. 4, fig. 3	**Nummulites (N.) henrici**
Pl. 14, fig. 25	Pl. 1, fig. 17	....	**Nummulites (N.) senni**

EXPLANATION OF PLATE 16

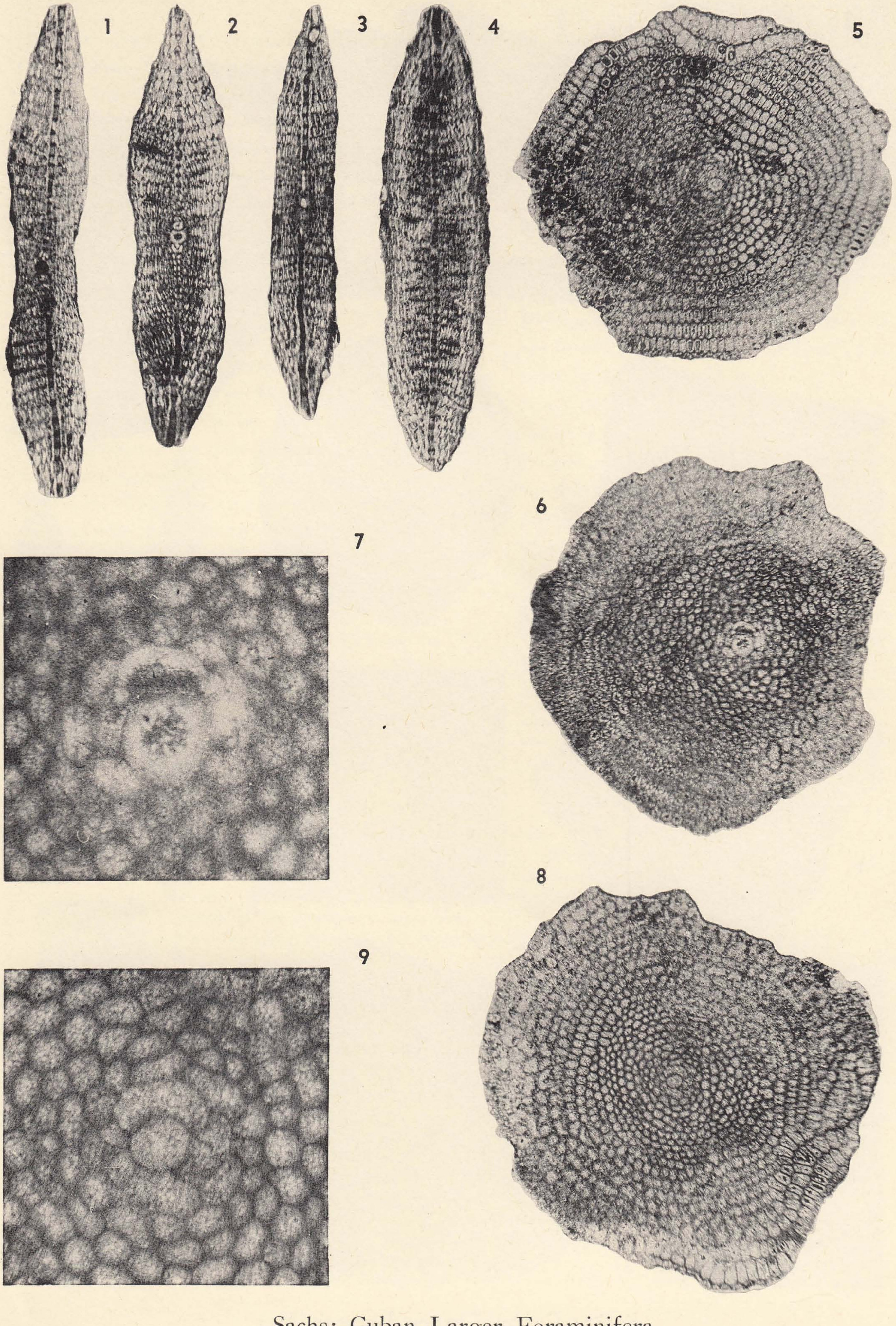
FIGS. PAGE

1-9. *Discocyclina (Discocyclina) cristensis* (Vaughan). 115

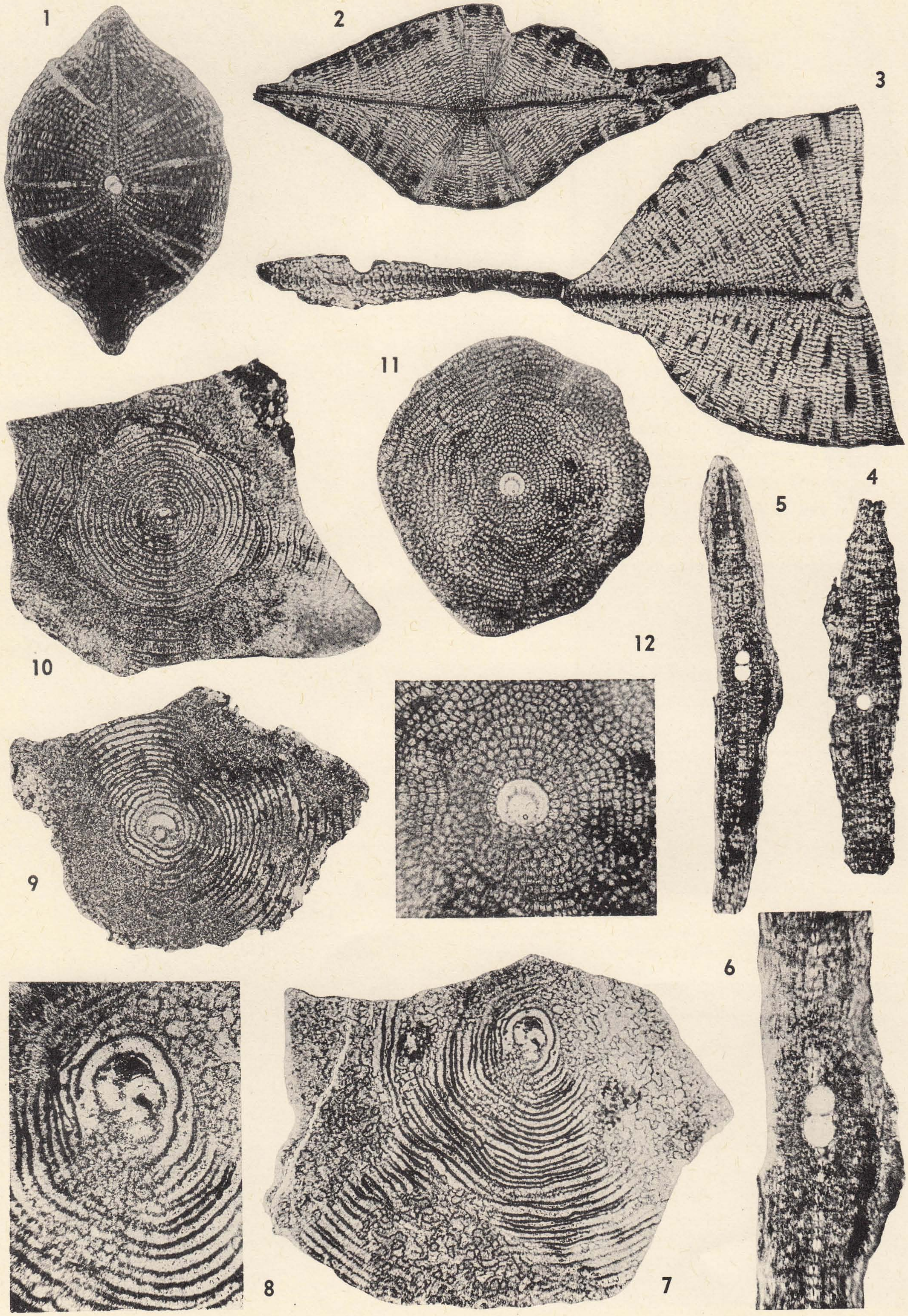
1-4. Vertical sections, ×20, to show variation in outline.

5, 6, 8. Equatorial sections, ×20.

7, 9. Parts of equatorial sections, ×160, to show the details of the embryonic apparatus; 7, illustrated by figure 6; 9, illustrated by figure 8.



Sachs: Cuban Larger Foraminifera



Sachs: Cuban Larger Foraminifera

Cole and Herrick (1953, p. 52) recognized that certain specimens found in wells in Georgia were the same as *Miscellanea soldadensis*, but erected a new specific name, *Operculinoides georgianus*, to include these and the Trinidad specimens because the name *O. soldadensis* was preoccupied by *Operculinoides soldadensis* Vaughan and Cole (1941, p. 40). This species was differentiated from *O. bermudezi* because it possessed a "more compressed test and less robust walls." A re-examination of Cole's preparations of this species has shown that they represent compressed members of the *O. bermudezi* series. It is quite easy to separate the most compressed representatives of *O. georgianus* from the more inflated specimens of *O. bermudezi* (compare pl. 14, figs. 13, 19), but the compressed members of the latter are quite similar to the more robust members of the former (compare pl. 14, figs. 12, 14). This is further illustrated in the scatter diagrams where it can be seen that the specimens of *O. georgianus* there plotted fall within the limits of *O. bermudezi.* The degree of development of the test wall is not felt to be a valid specific character as the specimens show considerable variation which may be due to factors arising from the environment. These specimens may have existed under less favorable conditions, and therefore developed thinner walls.

Family DISCOCYCLINIDAE

Genus **Discocyclina** Gümbel, 1870

Subgenus **Discocyclina** Gümbel, 1870

Discocyclina (Discocyclina) barkeri

Vaughan and Cole

Plate 15, figures 1-12

1941. *Discocyclina (Discocyclina) barkeri* VAUGHAN and COLE, Geol. Soc. Amer., Sp. Paper 30, pp. 57, 58, pl. 18, figs. 4-7; pl. 21, figs. 1, 2.

1945. *Discocyclina (Discocyclina) barkeri* VAUGHAN and COLE. VAUGHAN, Geol. Soc. Amer. Mem. 9, pp. 31, 32, pl. 6, figs. 1-10.

1947. *Discocyclina (Discocyclina) barkeri* VAUGHAN and COLE. COLE and BERMUDEZ, Bull. Amer. Paleont., vol. 31, no. 125, pp. 200-202, pl. 17, figs. 1-5; pl. 18, figs. 7-10.

1948. *Bontourina inflata* CAUDRI, Journ. Paleont., vol. 22, p. 477, pl. 73, fig. 6; pl. 74, fig. 5.

1951. *Discocyclina (Discocyclina) barkeri* VAUGHAN and COLE. DE CIZANCOURT, Soc. Géol. France, Mém. 64, vol. 30, n. ser., pp. 50, 51, pl. 4, figs. 18, 19; pl. 6, figs. 29, 30.

1951. *Bontourina* cf. *inflata* CAUDRI. DE CIZANCOURT, idem, pp. 55, 56, pl. 5, fig. 23; pl. 6, fig. 20.

EXPLANATION OF PLATE 17

FIGS. — PAGE

1, 11, 12. *Discocyclina (Discocyclina) mestieri* Vaughan ... 117

1. Vertical section, ×20, to illustrate the outline of the test, shape of the lateral chambers and faint curvature of the equatorial chamber walls.
11. Equatorial section, ×20, to illustrate the shape of the equatorial chambers.
12. Part of an equatorial section, ×40, illustrated by figure 11, to show the details of the embryonic apparatus.

2, 3. *Discocyclina (Discocyclina) marginata* (Cushman), introduced for comparison with *D. (D.) mestieri* ... 118

2, 3. Vertical sections, ×20, to illustrate the outline of the test, slit-like nature of the lateral chambers and the strong curvature of the equatorial chamber walls. 2, 3, collected by A. Senn from St. Bartholomew; 2, topotype from station SB21, section at the northern slope of the promontory separating Anse des Cayes and Baie de St. Jean; 3, station SB29, plateau of "Grand Bois" in the foot path from Gustavia to Anse du Gouverneur, at the first slight rise east of the bifurcation to St. Jean.

4-10. *Pseudophragmina (Athecocyclina) stephensoni* (Vaughan) ... 118

4, 5. Vertical sections, ×20; 4, after Cole and Herrick (1953, pl. 5, fig. 4) introduced for comparison.

6. Part of a vertical section, ×40, illustrated by figure 5.

7, 9, 10. Equatorial sections, ×20; 9 from Cole and Herrick (1953, pl. 5, fig. 10) introduced for comparison.

8. Part of an equatorial section, ×40, illustrated as figure 7, to show the details of the embryonic apparatus.

4, 9 from the Emily Harlow well, Seminole County, Georgia.

Tables 5 and 6 give the dimensions of 13 specimens of this species from Cuba. Subjoined to these for comparison are dimensions of one equatorial section of a topotype (Pl. 15, fig. 7) from Trinidad and of the 2 sections published by Caudri (1948, pl. 73, fig. 6; pl. 74, fig. 5) under the name *Bontourina inflata,* the type for that genus, which is here considered to be *D.* (*D.*) *barkeri.*

TABLE 5. Measurements from equatorial sections of megalospheric individuals of *Discocyclina* (*D.*) *barkeri*

	Plate 15									
Specimen	Fig. 3	Figs. 5, 10	Figs. 6, 8	Figs. 7, 11	*	—	—	—	—	—
Diameter (μ)	1.7	1.9	1.5	1.1	1.25	1.65	1.5	1.5	1.6	1.4
Diameter of embryonic apparatus (μ)										
Initial chamber	29x44	65x77	70x75	64x74	65	70x89	60	—	51	70
Second chamber	22x47	51x115	35x74	45x112	43x75	51x102	40x82	—	40x58	42x80
Diameter of equatorial chambers (μ)										
Radial	20-32	15-38	?-41	16-32	?-50	30-54	?-32	?-58	—	?-40
Tangential	22	26-32	26-32	22-32	?-40	32-38	?-32	?-32	—	?-30
Thickness of annular equatorial wall (μ)	15	5-10	13	5-10	—	8	5	—	—	10
Thickness of radial equatorial wall (μ)	15	5	9	5	—	6	5	20	—	6

* Specimen figured by Caudri (1948, pl. 74, fig. 5).

TABLE 6. Measurements from vertical sections of megalospheric individuals of *Discocyclina* (*D.*) *barkeri*

	Plate 15					
Specimen	Fig. 1	Fig. 2	Fig. 3	Fig. 4	Fig. 12	*
Diameter (mm.)	1.5	1.5	1.6	1.25	1.6	1.35
Thickness (mm.)	0.8	0.6	0.75	0.65	0.85	0.72
Height of initial chamber (μ)	61	51	38	65	65	48
Total diameter of embryonic apparatus (μ)	140	77	90	128	140	120?
Thickness of equatorial layer (μ)	16-30	13-32	19-38	22-32	—	18-?
Thickness of roof or floor of equatorial layer (μ)	6	9-13	10	7-13	—	6?
Height of lateral chambers (μ)	13-31	13-20	13-20	13-19	10-13	?-40?
Length of lateral chambers (μ)	16-51	19-38	26-61	32-77?	22-60	40?-60?
Thickness of lateral walls (μ)	6	7-10	6-10	7-10	6-12	—
Number of lateral layers	12	9	13	10	12	10
Width of pillars (μ)	32-45	19-45	26-38	26-45	20-32	--

* Specimen figured by Caudri (1948, pl. 73, fig. 6).

An equatorial section of a Cuban specimen (Pl. 15, figs. 5, 10) which very closely resembles the topotype (Pl. 15, figs. 7, 11) is described in detail: The embryonic apparatus consists of an initial subspherical chamber partly surrounded by a reniform second chamber. Two elongate periembryonic chambers which are separated by a smaller one occur on each side of the initial chamber and extend to a position slightly beyond the common wall between the initial and the second chamber. About 7 small, nearly rectangular chambers on the periphery of the second chamber complete the ring of periembryonic chambers.

The equatorial chambers are in definite annuli which become somewhat wavy toward the periphery. The chambers are rectangular, radially compressed near the center of the test, and square or slightly radially elongate near the periphery. The annular stolon is proximal (Pl. 15, fig. 9).

Another specimen, the surface of which was covered with small papillae about 30 to 35μ in diameter and which had an inflated lenticular outline, was first ground to the equatorial layer for study, after which it was made into a vertical thin section (Pl. 15, fig. 3). A description of the equatorial section follows:

The embryonic apparatus of this specimen consisted of a subspherical initial chamber with a reniform second chamber appressed against one side. Presumably 2 elongate periembryonic chambers, which were separated by 3 smaller ones, lay on each side of the initial chamber between the extremities of the common wall between the initial and second chambers. About 4 small chambers around the periphery of the second chamber completed the ring of periembryonic chambers. The equatorial chambers were in definite annuli, and those near the center of the test were faintly hexagonal and radially compressed. Towards the periphery they became somewhat radially elongate and rectangular although the faint hexagonal shape remained in many places. Radial and annular walls were relatively thick. Examination of the vertical section (Pl. 15, fig. 3) made from this specimen will demonstrate that the equatorial section on which the above description was based was slightly oblique.

In the vertical hemi-section, whose dimensions are given in table 5, the embryonic apparatus is bilocular. The equatorial layer is thinnest at the center of the test and expands slightly towards the periphery. The equatorial chamber walls are thin, about 5μ thick, apparently straight near the center of the test but becoming slightly convex outward near the periphery. Lateral chambers are well defined, open, and in regular tiers which are separated by strong pillars over the center of the test. The pillars become weak near the periphery. Lateral chamber walls are straight and thin near the periphery but become slightly thicker towards the center of the test. The extremities of the lateral chamber walls of adjacent tiers alternate in position where pillars are weak or absent.

Remarks.—Figures 6 and 8 of Plate 15 illustrate an oblique equatorial section similar to that of the specimen from which the hemi-section described above was made. The difference in appearance of these two equatorial sections is owing to the fact that the first was accurately centered while the second was oblique, causing the destruction of most of the equatorial chambers.

Caudri's illustration of *Bontourina inflata* (1948, pl. 74, fig. 5) appears to be either oblique or the plane of the equatorial layer was undulate. The illustrations and descriptions of *B. inflata* are not clear; however, the features which do show are unmistakable and similar to those developed by *D. (D.) barkeri*. Therefore, there was no valid reason for the separation of a new species. The faint hexagonal shape of the equatorial chambers in *B. inflata* as described by Caudri and as illustrated by figures 6 and 9 of Plate 15 are apparent, but it is a question whether the development of this type of chamber is of sufficient importance to warrant generic rank to the species having it.

If the following illustrations are compared, it will be observed that they represent only one species.

Caudri (1948)	This article	Cole & Bermudez (1947)
Bontourina inflata	**D. (D.) barkeri**	**D. (D.) barkeri**
pl. 74, fig. 5	pl. 15, fig. 6	pl. 18, fig. 8
pl. 73, fig. 6	pl. 15, figs. 1-4, 12	pl. 18, fig. 7

Vaughan (1945, p. 66) has stated in discussing *Asterocyclina* and *Discocyclina*, "In both subgenera the chamber walls may show a tendency toward faintly hexagonal outlines, a condition not surprising, because the radial walls in adjacent annuli alternate in position." This relationship is shown clearly in figure 9, Plate 15.

Inasmuch as the other features—including an annular stolon on the proximal side of the equatorial chambers, intraseptal canals and the alternating position of radial chamber walls—are the same as described for certain species of *Discocyclina* which do not have faintly hexagonal equatorial chambers, it is believed that these are a specific rather than generic feature.

Discocyclina (Discocyclina) cristensis (Vaughan)

Plate 16, figures 1-9

1924. *Orbitoclypeus? cristensis* VAUGHAN, Geol. Soc. Amer., Bull., vol. 35, pp. 814-815, pl. 36, fig. 8.

1929. *Discocyclina cristensis* (VAUGHAN). VAUGHAN, U. S. Nat. Mus. Proc., vol. 76, art. 3, pp. 8, 9, pl. 2, figs. 1, 2.

1944. *Hexagonocyclina cristensis* (VAUGHAN). CAUDRI, Bull. Amer. Paleont., vol. 28, no. 114, p. 362.

1945. *Discocyclina (Discocyclina) cristensis* (VAUGHAN). VAUGHAN, Geol. Soc. Amer., Mem. 9, pp. 74, 75, pl. 25, fig. 1.

1951. *Discocyclina (Discocyclina) cristensis* (VAUGHAN). DE CIZANCOURT, Soc. Géol. France, Mém. 64, vol. 30, n. ser., pp. 51, 52, pl. 5, figs. 24, 25.

1951. *Bontourina saturniformis* DE CIZANCOURT, idem, p. 55, pl. 5, fig. 18; pl. 6, figs. 25, 26, 31, 32.

The test is small, either depressed centrally or compressed lenticular, and probably has a thin flange. The surface is covered with fine granules about 40μ in diameter which are most prominent on the umbonal area of the test.

Measurements of 15 specimens are given in tables 7, 8, and 9.

TABLE 7. Measurements from free specimens of *Discocyclina (D.) cristensis*

Specimen	1	2	3	4	5
Diameter (mm.)	1.85	1.6	1.7	1.6	1.5
Maximum thickness (mm.)	0.25	0.45	0.4	0.3	0.5

TABLE 8. Measurements from equatorial sections of megalospheric individuals of *Discocyclina (D.) cristensis*

	Plate 16					
Specimen (Figures)	5	6, 7	8, 9	—	—	—
Diameter (mm.)	1.45	1.6	1.75	1.85	1.7	1.75
Diameter of initial embryonic chamber (μ)	64	90	63	60	90	64
Diameter of second embryonic chamber (μ)	70	90	95	134	105	109
Radial diameter of equatorial chambers (μ)	26-96	32-65	25-90	50-60	32-70	—
Tangential diameter of equatorial chambers (μ)	26-32	38-51	32-48	30	32-64	—

TABLE 9. Measurements from vertical sections of megalospheric individuals of *Discocyclina (D.) cristensis*

	Plate 16			
Specimen	Fig. 1	Fig. 2	Fig. 3	Fig. 4
Diameter (mm.)	1.95	1.75	1.6	1.8
Thickness at center (mm.)	0.23	0.33	0.23	0.38
Maximum thickness (mm.)	0.3	0.39	0.28	0.38
Number of lateral layers	5	6	5	7
Height of lateral chambers (μ)	6-12	6-9	9-13	13
Length of lateral chambers (μ)	40-60	20-30	40-50	30-40
Thickness of lateral walls (μ)	8	5-20	5-15	6
Height of equatorial chambers (μ)	26-38	13-55	25-55	26-55
Thickness of roof or floor of equatorial layer (μ)	—	9-13	6-13	6-13
Diameter of embryonic apparatus (μ)	45x77	64x96	—	—

Equatorial sections.—The embryonic chambers in the best equatorial section (Pl. 16, figs. 8, 9) are bilocular, consisting of a subcircular initial chamber which is partially embraced by a reniform second chamber. The embryonic chambers are surrounded by a zone composed of small, irregularly arcuate equatorial chambers which are replaced toward the periphery with annuli composed of radially elongate equatorial chambers, many of which have a faint hexagonal shape.

In two other equatorial sections (Pl. 16, figs. 5-7) the zone adjacent to the embryonic chambers was not as clearly exposed as in the section described above. They show in general the same features and, therefore, need not be described in detail. However, these sections do show that when the equatorial section is not exactly oriented the equatorial chambers are more irregular in shape and arrangement than in centered sections. The annular stolon in all the sections is proximal in position.

Vertical sections.—Certain specimens (Pl. 16, figs. 2, 3) apparently had a thin flange surrounding the test although this has been removed partially by erosion. The equatorial layer is thin with a thick roof and floor, both of which thicken slightly toward the periphery. There are 5 to 10 layers of lateral chambers, generally in regular tiers separated by weak pillars except over the depressed central area where the tiers of lateral chambers become irregular. These chambers are open and do not change appreciably in size from the center of the test to the periphery, although they do become somewhat longer toward the surface of the test. The central depressed area observed in certain specimens is due to a thickening of the walls of the lateral chambers in the surrounding inflated area rather than to an increase in height of the cavities of these chambers. The lateral walls are either straight or faintly convex outward.

Remarks.—The original figure and description of this species are clear, although a vertical section was not available at the time. Comparison of Vaughan's figure with figures 5 and 8 in Plate 16 will demonstrate the close similarity between these specimens. Vaughan (1929, p. 8, pl. 2, figs. 1, 2) redescribed this species, transferring it from the genus *Orbitoclypeus* to *Discocyclina.* His illustrations are excellent and should be compared with those given here in Plate 16. The similarities are so obvious that there can be little doubt that only one species is represented.

Although certain specimens of *D. (D.) cristensis* with a central depression superficially resemble *D. (D.) grimsdalei* Vaughan and Cole, they are smaller, the initial chamber is not entirely surrounded by the second chamber and the equatorial chambers are in places faintly hexagonal whereas those of *D. (D.) grimsdalei* are rectangular in shape.

Caudri (1944, p. 362) made *D. (D.) cristensis* the genotype of a new genus, *Hexagonocyclina.* Vaughan (1945, p. 74, pl. 25, fig. 1) restudied this species and concluded that it was assigned correctly to the genus *Discocyclina* and that *Hexagonocyclina* was a synonym of *Discocyclina.* Later, Caudri (1948, p. 477, pl. 73, fig. 6; pl. 74, fig. 5) erected a new genus, *Bontourina,* for the other species previously placed in *Hexagonocyclina,* designating *Bontourina inflata* the genotype. It has been demonstrated under the remarks for *D. (D.) barkeri* that the hexagonal shape of the equatorial chambers characteristic of *Bontourina* is not a generic character and that *B. inflata* is a synonym of *D. (D.) barkeri.*

De Cizancourt (1951, p. 51, pl. 5, figs. 24, 25) identified several Venezuelan specimens as *D. (D.) cristensis.* However, in the same article (1951, p. 55) she described a new species, *Bontourina saturniformis,* illustrating 2 vertical sections (1951, pl. 5, fig. 18; pl.

6, fig. 25) and drawings of parts of several oblique sections (1951, pl. 6, figs. 26, 31, 32). This new species was based only on vertical and incomplete equatorial sections from which the character of the embryonic apparatus could not be determined. Characteristics of the species are hexagonal equatorial chambers, a slightly depressed central area and a thin flange formed by the prolongation of the equatorial layer beyond the zone of the lateral chambers. If her illustrations of this species are compared with the illustrations of *D.* (*D.*) *cristensis* given here (Pl. 16, figs. 1-9), and by Vaughan (1924, pl. 36, fig. 8; 1929, pl. 2, figs. 1, 2; 1945, pl. 25, fig. 1), and also with her illustrations of *D.* (*D.*) *cristensis* in the same paper (Pl. 5, figs. 24, 25), the similarities will be so obvious that there can be little doubt that *B. saturniformis and D.* (*D.*) *cristensis* represent but one species.

As nearly as can be determined, the equatorial chambers are alike in all cases. The slight central depression is not uncommon in this species, and the flange, although usually destroyed, is in all likelihood present on typical specimens of *D.* (*D.*) *cristensis.*

Discocyclina (Discocyclina) mestieri Vaughan

Plate 17, figures 1, 11, 12

1945. *Discocyclina* (*Discocyclina*) *mestieri* VAUGHAN, Geol. Soc. Amer., Mem. 9, pp. 37, 38, pl. 12, figs. 1-6.

1951. *Discocyclina* (*Discocyclina*) *mestieri* VAUGHAN. DE CIZANCOURT, Soc. Géol. France, Mém. 64, vol. 30, n. ser., p. 52, pl. 4, fig. 17.

Tables 10 and 11 give pertinent dimensions of specimens of *Discocyclina* (*Discocyclina*) *mestieri* from Cuba.

TABLE 10. Measurements from equatorial sections of megalospheric individuals of *Discocyclina* (*D.*) *mestieri*

	Plate 17		
Specimen	Figs. 11, 12	—	—
Diameter (mm.)	2.4	2.55	3.25
Diameter of embryonic apparatus (μ)			
Initial chamber	128	—	134
Second chamber	185x200	ca. 220	255x230
Radial diameter of equatorial chambers (μ)			
Proximal	38	32	32
Distal	51	30	50
Tangential diameter of equatorial chambers (μ)			
Proximal	32	32	26
Distal	32	25	32
Number of equatorial chambers in initial annulus	19	20	22

TABLE 11. Measurements from vertical sections of megalospheric individuals of *Discocyclina* (*D.*) *mestieri*

	Plate 17			
Specimen	Fig. 1	—	—	—
Total diameter (mm.)	2.7	2.5	2.7	2.2
Diameter of umbo (mm.)	2.15	2.0	2.25	1.5
Thickness of umbo (mm.)	1.8	1.45	1.5	1.5
Number of lateral layers	20	20	23	22
Length of lateral chambers (μ)	30-128	30-75	30-51	60-90
Height of lateral chambers (μ)	5-20	5-25	10-20	5-13
Thickness of lateral walls (μ)	13-32	25	13-32	13-25
Height of equatorial chambers (μ)	16-38	32	19-35	13-20
Thickness of equatorial roof or floor (μ)	20-30	13	13-16	10-20
Diameter of initial embyronic chamber (μ)	96 x122	100 x140	140 x160	—
Thickness of wall between first and second embryonic chambers (μ)	30	—	7	—

Equatorial sections.—The embryonic apparatus of all specimens consists of an initial spherical chamber either completely surrounded by or attached to the inside wall of a larger second chamber. An annulus of about 20 square or nearly square equatorial chambers surrounds the embryonic apparatus. Succeeding annuli are definite, but may be wavy. The equatorial chambers, square or nearly square near the center of the test, change little in size and shape toward the periphery until the region of the flange is reached. Here there is an appreciable radial elongation of the chambers. The radial walls of adjacent annuli have a tendency to become aligned in this area in some specimens, whereas they clearly alternate near the center. However, the annular stolon is in a proximal position in all instances where observed.

Vertical sections.—The variation in size and shape of the embryonic apparatus is well illustrated by the dimensions given in Table 11 and needs no further discussion other than to state that variation in vertical section is largely dependent upon the orientation of the section.

The equatorial layer is thin, ranging in thickness from about 15 to 30μ near the center of the test to about 25 to 65μ at the periphery. The maximum height of 65μ is attained only in specimens where the flange is more or less complete. The roof and floor of the equatorial layer vary between 15 and 30μ in thickness, and are thinnest at the center of the test.

Lateral chambers occur in definite tiers with approximately 20 layers over the center of the test. The lateral chambers are generally short and open with a maximum length of approximately 100μ and a maximum height of approximately 25μ. The lateral walls are thickest near the center of the test where the chambers are more slit-like. The maximum thickness observed for the lateral walls was 35μ. The lateral wall thickness may be as low as 10 to 15μ where the chambers are most open near the periphery. Pillars are numerous, especially over the umbo where they are often quite prominent, thick, and in some cases bifurcated.

Remarks.—Cole and Gravell (1952, p. 714), in studying *D.* (*D.*) *crassa*, *D.* (*D.*) *harrisoni*, *D.* (*D.*) *californica*, and *D.* (*D.*) *marginata* came to the conclusion that they were identical and should all be combined as one species, *D.* (*D.*) *marginata*. At the same time, two of the specimens of *D.* (*D.*) *mestieri* illustrated by Cole and Bermudez (1947, pl. 17, fig. 7; pl. 20, fig. 4) were also transferred to *D.* (*D.*) *marginata*. The rest were retained under *D.* (*D.*) *mestieri* (Pl. 17, figs. 6, 8-10; pl. 16, fig. 3).

Examination of several inflated specimens in the present collection showed them to have characters which seemingly were common both to *D.* (*D.*) *marginata* and *D.* (*D.*) *mestieri*. Therefore, Cole's Cuban specimens from Peñon Seep and Bermudez station 1266 were restudied. Morever, thin sections of topotypes of *D.* (*D.*) *marginata* (Pl. 17, figs. 2, 3), collected by A. Senn from St. Bartholomew, were examined and compared with the Cuban specimens. In addition, random thin sections of specimens which seemingly were *D.* (*D.*) *weaveri* Vaughan from the lower Eocene of Haiti were made available by J. Butterlin.

Study of these suites of specimens demonstrated that *D.* (*D.*) *mestieri*, *D.* (*D.*) *marginata*, and *D.* (*D.*) *weaveri* are closely related species. However, a number of constant differences were noted which seem to justify the retention of all three as distinct species at the present time.

Externally, *D.* (*D.*) *weaveri* is lenticular, whereas *D.* (*D.*) *mestieri* and *D.* (*D.*) *marginata* are strongly umbonate and possess an equatorial flange. The initial embryonic chamber of *D.* (*D.*) *weaveri* in equatorial section is elliptical to pyriform in shape whereas *D.* (*D.*) *mestieri* and *D.* (*D.*) *marginata* have a spherical to subspherical initial chamber. The equatorial chambers of *D.* (*D.*) *weaveri* are equidimensional and thick walled, those of *D.* (*D.*) *mestieri* are equidimensional, except in the area of the flange, and thin walled, and those of *D.* (*D.*) *marginata* are radially elongate and thin walled. The equatorial chamber walls of *D.* (*D.*) *weaveri* in vertical section are moderately convex outward, those of *D.* (*D.*) *mestieri* are straight or faintly convex outward, and those of *D.* (*D.*) *marginata* are strongly convex outward. The lateral chambers of *D.* (*D.*) *weaveri* are open and elongate with moderately thick walls, those of *D.* (*D.*) *mestieri* are open and short with moderately thick walls, and those of *D.* (*D.*) *marginata* are slit-like with very thick walls.

Cole (Cole and Gravell, 1952, p. 715) had decided that certain specimens from Bermudez station 1266, originally assigned to *D.* (*D.*) *mestieri*, were *D.* (*D.*) *marginata*. If the morphological criteria cited above are valid, the other specimens, retained by Cole (Cole and Gravell, 1952, p. 715) in *D.* (*D.*) *mestieri*, must be transferred also to *D.* (*D.*) *marginata*.

To date, *D.* (*D.*) *marginata* has been reported only from the middle Eocene in the Caribbean area but *D.* (*D.*) *mestieri* and *D.* (*D.*) *weaveri* have been recorded only from the Paleocene and lower Eocene.

Genus **Pseudophragmina Douvillé**, 1923
Subgenus **Athecocyclina** Vaughan and Cole, 1940
Pseudophragmina (Athecocyclina) stephensoni (Vaughan)

Plate 17, figures 4-10

1929. *Discocyclina stephensoni* VAUGHAN, U. S. Nat. Mus. Proc., vol. 76, art. 3, p. 16, pl. 6, figs. 1-4.
1941. *Pseudophragmina stephensoni* (VAUGHAN). VAUGHAN and COLE, Geol. Soc. Amer., Sp. Paper 30, p. 63.
1953. *Pseudophragmina* (*Athecocyclina*) *stephensoni* (VAUGHAN). COLE and HERRICK, Bull. Amer. Paleont., vol. 35, no. 148, pp. 8-10, pl. 2, figs. 4-11.

The test is small, either compressed lenticular or nearly flat. The surface is covered with small papillae about 20 to 30μ in diameter.

Table 12 gives pertinent dimensions of thin sections of 4 specimens referred to this species.

TABLE 12. Measurements from equatorial sections of megalospheric individuals of *Pseudophragmina* (*A.*) *stephensoni*

	Plate 17	Plate 17		
Specimen	Figs. 7, 8	Fig. 10	....	....
Diameter (mm.)	4.0	3.8	3.5	3.6
Diameter of embryonic apparatus (μ)				
Initial chamber ...	147	—	—	90x100
Second chamber ..	115x260	135	—	70x140
Diameter of equatorial chambers (μ)				
Radial	20-55	50-60	50	65
Tangential	10-15	13-32	25	25
Thickness of annular walls (μ)	20	6-10	15-20	10-15
Number of annuli	37	28	35	36

Equatorial section.—The embryonic apparatus consists of an initial spherical chamber partly embraced by a reniform second chamber. A single undivided annulus averaging 60μ in width surrounds the embryonic chambers. The walls of the succeeding equatorial annuli are wavy and have small granules or projections on their distal margins from which indistinct radial walls can be observed to project outward in some places. The width of the annuli increases slightly from the center to the periphery of the test. The radial walls where seen are aligned in adjacent annuli. The annular stolon lies along the distal margins of the annuli.

Vertical section.—The equatorial layer is thin with moderately thick roof and floor. The lateral chambers are narrow but open between thick lateral walls.

Remarks.—Table 13 was prepared from the original descriptions of *P.* (*A.*) *stephensoni* and *P.* (*A.*) *cookei* after Vaughan (1929, p. 16, pl. 6, figs. 1-4; 1936, p. 256, pl. 42, figs. 1-6), to which have been subjoined measurements from the specimen illustrated in figures 5 and 6 of Plate 17. The close similarity of these is at once apparent. The only difference which may be considered significant occurs in the character of the lateral chambers. Those of *P.* (*A.*) *stephensoni* are more open and the roofs are thicker than those of *P.* (*A.*) *cookei.* Unfortunately, an insufficient number of specimens was available for a more detailed study of the relationship of these two species.

TABLE 13. Average dimensions from equatorial and vertical sections of *Pseudophragmina* (*A.*) *stephensoni* and *P.* (*A.*) *cookei*

	Vaughan (1929)	Vaughan (1936)	This article
Specimen (species)	**P. (A.) stephensoni**	**P. (A.) cookei**	Pl. 17, figs. 5, 6
Diameter (mm.)	4.5-5	4-7	3.6
Thickness (mm.)	0.5	0.4	0.6
Diameter of initial embryonic chamber (μ)	140	135	—
Width of equatorial annuli (μ)	50	38-76	—
Height of equatorial chambers (μ)	25-40	22-30	13-20
Thickness of roof or floor of equatorial layer (μ)	25-40	22-30	13-15
Height of lateral chambers (μ)	12-24	5-8	10
Length of lateral chambers (μ)	40-100	—	32
Thickness of lateral walls (μ)	16-32	9-20	20
Number of layers of lateral chambers	5-6	—	7

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CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME VIII, PART 3, JULY, 1957

173. NOTES ON *ANOMALINOIDES VANBELLENI* TEN DAM AND SIGAL, *ANOMALINOIDES GRANOSA* (HANTKEN), *GAVELINELLA DANICA* (BROTZEN), AND *ANOMALINOIDES CAPITATUS* (GÜMBEL)

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Van Bellen (1957) suggests that a species described by him from the Montian of Holland (erroneously determined by him as Eocene), a species described by ten Dam and Sigal from the Dano-Montian of Algeria, and *Truncatulina granosa* Hantken 1875 all belong to the same species. He bases this synonymy on the coarse perforation and rounded periphery. A close analysis of all three species from the type localities gives quite a different result.

Hofker (1955) has given the whole development series of *Gavelinella danica* (Brotzen) from the upper Maestrichtian up through the Montian in Holland and Belgium. The Montian specimens are those called by van Bellen (1946) *Anomalinoides granosa* and are compared with his types. This species, undoubtedly Brotzen's species, forms an unbroken series from the upper Maestrichtian (Cr 3 c) through Cr 4, the entire M-complex, the lower Paleocene, the Tuffeau de Ciply up into the tropical marine Montian (van Bellen's Eocene); it differs greatly from Hantken's *Cibicides* (*Anomalinoides?*) *granosa* as may be seen by comparing Hofker's drawings with the photographs on van Bellen's plate (1957). The main difference lies in the dorsal side which in *G. danica* always shows the initial chambers, whereas in *A. granosa* the chambers completely overlap this part. Moreover, sections reveal that the two species, van Bellen's *A. granosa* from the Dutch marine Montian and Hantken's *A. granosa* from the *Clavulina szaboi*- beds of Hungary, possess a quite different inner structure, *A. granosa* from Hungary being a true *Cibicides, A. granosa* (*Gavelinella danica*) from the Dutch Montian being a true *Gavelinella*.

Specimens from the Dano-Paleocene of Algeria and Tunisia do not differ from those found in Holland in the lower Paleocene and Montian. Thus, *Anomalinoides vanbelleni* ten Dam and Sigal is identical with the latest development stages of *Gavelinella danica* (Brotzen) and must be a synonym of that species. It is, however, not a synonym of *A. granosa* (Hantken).

Hagn (1956, p. 176, pl. 16, figs. 15, 16) has already shown the true solution of the correct name for the species which shows the inner structure of *Cibicides*. According to him *Truncatulina granosa* Hantken 1875 and *Anomalina dorri* Cole 1928 are both synonyms of *Anomalinoides capitatus* (Gümbel); the author can confirm this opinion. But contrary to the opinion of Hagn, the author is certain of the synonymousness of *Anomalinoides vanbelleni* and *Gavelinella danica*. Thus we have:

Danian and Paleocene	*Gavelinella danica* synonymous with *Anomalinoides vanbelleni*
Eocene	*A. capitatus* synonymous with *Truncatulina granosa* and *Anomalina dorri*

Anomalinoides granosa van Bellen (not Hantken) from the Montian of Holland (and the type locality at Mons in Belgium) is synonymous with *G. danica* (Brotzen).

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BELLEN, R. C. VAN, 1946, Foraminifera from the middle Eocene in the southern part of Netherlands province of Limburg: Med. Geol. Stichting, Ser. C-V-No. 4, p. 74, pl. 11, figs. 4-6.

———, 1957, *Anomalinoides vanbelleni* ten Dam and Sigal, a synonym of *Anomalinoides granosa* (Hantken, 1875): Contr. Cushman Found. Foram. Res., vol. 8, pt. 1, p. 9.

HAGN, H., 1956, Geologische und paläontologische Untersuchungen im Tertiär des Monte Brione und seiner Umgebung: Palaeont., vol. 107, pt. A., pp. 68-210, pls. 7-18.

HOFKER, J., 1955, Foraminifera from the Cretaceous of southern Limburg, Netherlands, III. *Gavelinella danica*: Nat. Maandblad, vol. 44, no. 5-6, pp. 49-53, 2 text figs.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
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RECENT LITERATURE ON THE FORAMINIFERA

Below are given some of the more recent works on the Foraminifera that have come to hand.

ASANO, KIYOSHI. The Foraminifera from the Adjacent Seas of Japan, collected by the S. S. **Soyo-maru,** 1922-1930. Part 3, Planktonic Foraminifera.—Sci. Repts. Tohoku Univ., Sendai, 2nd ser. (Geol.), v. 28, 1957, p. 1-26, pls. 1, 2, text figs. 1, 2 (maps).—Twenty-one species, one **(Globigerina nipponica)** new, nearly all illustrated.

ASCOLI, P. Microfaune della serie Eocenica di Rio Repregoso e della serie Oligocenica superiore di Mombisaggio-Mongariolo (Tortona-Alessandria).—Riv. Ital. Pal. Stratig., v. 62, No. 3, 1956, p. 153-196, pls. 13-16, text figs. 1-6, tables 1, 2.—Comparison of these mainly planktonic faunas with those of the Appennines and the Antillean region, particularly Trinidad. Four zones recognized in the upper Eocene, based on planktonics.

AYGEN, TEMUCIN. Etude Géologique de la Région de Balya (French résumé).—Publ. Instit. Etudes Recherches Min. Turquie, ser. D, No. 11, 1956, p. 1-95, pls. 1-4 (maps), photos 1-63.—Lists and illustrations of fusulinids.

BARTENSTEIN, HELMUT. Zur Mikrofauna des englishen Hauterive.—Senckenbergiana Lethaea, Band 37, No. 5/6, Dec. 15, 1956, p. 509-533, pls. 1-3, text figs. 1-4.—Forty-five species and subspecies recorded and illustrated; 2 new.

BLOW, W. H. Transatlantic correlation of Miocene sediments.—Micropaleontology, v. 3, No. 1, Jan. 1957, p. 77-79.—Evidence from Malta and Sicily bearing on placement of Burdigalian/Aquitanian boundary in the Trinidad section.

BOLTOVSKOY, ESTEBAN. Diccionario Foraminiferologico Plurilingüe.—Argentina Ministerio de Marina, Direccion General de Navegacion e Hidrografia, S. H. Pub. Misc. No. 1001, 1956, 196 p.—An invaluable list of over 2000 terms relating to Foraminifera, giving equivalents in English, Spanish, German, French, and Russian, and including complete cross references.

Las Anormalidades en las Caparazones de Foraminiferos y el "Indice de Regeneramiento."—Ameghiniana, v. 1, Nos. 1-2, Jan. 1957, p. 80-84.—**Elphidium** found to have the greatest capacity for regeneration after mechanical damage to the shell.

BOWEN, R. N. C. Smaller Foraminifera from the upper Eocene of Barton, Hampshire, England.—Micropaleontology, v. 3, No. 1, Jan. 1957, p. 53-60, pl. 1, text figs. 1-2.—Twenty-one species and one variety (none new).

BROWN, NOEL K., JR., and BRONNIMANN, PAUL. Some Upper Cretaceous rotaliids from the Caribbean region.—Micropaleontology, v. 3, No. 1, Jan. 1957, p. 29-38, pl. 1, text figs. 1-30.—Six species (one new) from reef deposits, and discussion of their paleoecology.

BUDAY, TIBOR, and CICHA, IVAN. Neue Ansichten über die Stratigraphie des unteren und mittleren Miozäns des Inneralpinen Wiener Beckens und des Waagtales (German résumé).—Geol. Práce, No. 43, 1956, p. 3-56, pls. 1-5, table, chart.—Distribution and abundance are indicated for 80 species, many illustrated.

CHANG, LI-SHO. Two species of **Lingulina** from the Miocene of Taiwan.—Bull. Geol. Survey Taiwan, No. 8, Dec. 1956, p. 65, 66, pl. 1.

A new **Spiroplectammina** from the Miocene of Taiwan —Bull. Geol. Survey Taiwan, No. 8, Dec. 1956, p. 67, 68, pl. 1.

COLE, W. STORRS. Late Oligocene Larger Foraminifera from Barro Colorado Island, Panama Canal Zone (with a detailed analysis of American miogypsinids and heterosteginids).—Bull. Amer. Pal., v. 37, No. 163, March 1, 1957, p. 309-338, pls. 24-30.—Eleven species recorded from 6 localities on Barro Colorado. Review of miogypsinids results in recognition of 5 American species. Review of heterosteginids results in recognition of 4 species in the American Eocene and Oligocene. Nine species are illustrated.

CONKIN, JAMES E., and CONKIN, BARBARA M. **Haplophragmoides coahuilaensis,** a new species from the Lower Cretaceous of Mexico.—Micropaleontology, v. 3, No. 1, Jan. 1957, p. 65-66, text figs. 1-3, table 1.

DARDENNE, M. Paléontologie et écologie du Miocène Marocain (Région du Zegotta).—Notes du Service Géol. du Maroc, tome IX, Notes et Mém. No. 121, 1954, p. 31-76, pls. 1-3 (photographs), pls. 1-10 (charts and graphs).—Interpretation of evolution of marine environment throughout the Vindobonian is based on already recorded depth and temperature ranges of 48 species and 11 genera of Recent Foraminifera that also occur in the Miocene, and on frequency variations of family groups in some 60 samples.

DROOGER, C. W. Parallel evolutionary trends in Larger Foraminifera.—Proc. Kon. Nederl. Akad. Wetenschappen, ser. B, v. 59, No. 5, 1956, p. 458-469, text figs. 1-6.—Trends toward greater radial symmetry.

EAMES, F. E., and CLARKE, W. J. The ages of some Miocene and Oligocene Foraminifera.—Micropaleontology, v. 3, No. 1, Jan. 1957, p. 80.—Suggested corrections of ranges.

ELIAS, MAXIM K. Late Mississippian fauna from the Redoak Hollow formation of southern Oklahoma, Part I.—Journ. Pal., v. 31, No. 2, March 1957, p. 370-427, pls. 39-50.—Includes four foraminifers, one a new variety in **Ptychocladia.**

FERREIRA, J. MARTINS, and ROCHA, A. TAVARES. Contribuição para o estudo dos Foraminíferos fósseis do Túnel do Rossio.—Bol. Lisbon Univ. Mus. Lab. Min. Geol., ser. 7, No. 23, 1955, p. 105-117, 1 pl.—Ten species and a subspecies, none new.

FEYLING-HANSSEN, ROLF W. Micropaleontology applied to soil mechanics in Norway.—Norges Geol. Undersökelse, Nr. 197, 1957, p. 1-69, pls. 1-3, text figs. 1-22, 3 tables.—Marine clays of Late Glacial and Post

Glacial age are divided into 7 zones on the basis of their Foraminifera content, and ecologic interpretations made. Shear strength may be correlated with the stratigraphy of a clay deposit hence micropaleontology may be applied to the tracing of land slides.

GANS, O. Geologie des Blattes Bergen.—Geologica Bavarica, No. 26, 1956, p. 1-164, text figs. 1-7, tables 1, 2, maps, sections, range charts.—Includes numerous lists of Foraminifera and illustrated range charts containing 10 planktonic species significant in the lower Tertiary and 49 species significant in the Upper Cretaceous.

GIANNOTTI, AGOSTINO. Sulla presenza e sul valore stratigrafico di **Globigerinatheka** Bronnimann in Sicilia.—Riv. Min. Siciliana, No. 40-41, July-Oct. 1956, p. 1-12, pls. 1, 2, text figs. 1-5.—Occurrence of worldwide upper Eocene planktonic fauna with many species known also in Spain and Caribbean area.

GULLENTOPS, F. Les foraminifères des sables de Vieux-Joncs (Tongrien supérieur).—Mem. Instit. Geol. Univ. Louvain, Tome 20, fasc. 1, 1956, p. 1-25, pl. 1. —Thirteen species, 5 new, from the upper part of the lower Oligocene.

HAMILTON, EDWIN L. Planktonic Foraminifera from an Equatorial Pacific core.—Micropaleontology, v. 3, No. 1, Jan. 1957, p. 69-73.—Near the equator the same warm-water faunas lived continuously throughout the Pleistocene.

HANZAWA, SHOSHIRO. Cenozoic Foraminifera of Micronesia.—Geol. Soc. Amer., Mem. 66, Febr. 28, 1957, p. 1-163, pls. 1-41, text figs. 1-12, tables 1-7.—Seventy-seven species and varieties, most of them larger Foraminifera and mostly from Saipan, 11 new, are described and illustrated. **Kanakaia** n. gen. (genotype **K. marianensis** n. sp.), similar to **Keramosphaera**, and **Ladoronia** n. subgenus (subgenotype **Acervulina (Ladoronia) vermicularis** n. sp.) are erected. Strata of Eocene to Pleistocene age are included in the study. The families Nummulitidae and Miogypsinidae are reviewed with several genera being suppressed as synonyms.

HAQUE, ABUL FAZAL MOHAMMAD MOHSENUL. The smaller Foraminifera of the Ranikot and the Laki of the Nammal Gorge, Salt Range.—Palaeontologia Pakistanica, v. 1, 1956, p. 1-300, pls. 1-35, text figs.—From 48 samples of the Ranikot (Paleocene) and Laki (upper Paleocene and lower Eocene) formations, about 215 species and varieties were found, of which 56 species and 32 varieties are new. Four zones established on the basis of smaller Foraminifera cover a stratigraphic thickness of about 900 feet. New genera are: **Globanomalina** (genotype **G. ovalis** n. sp.), **Punjabia** (genotype **P. ovoidea** n. sp.), **Sakhiella** (genotype **S. nammalensis** n. sp.), **Pseudogloborotalia** (genotype **P. ranikotensis** n. sp.), **Woodella** (genotype **W. granosa** n. sp.), **Ornatanomalina** (genotype **O. geei** n. sp.), and **Pseudowoodella** (genotype **P. mamilligera** n. sp.); the first three being placed in the Rotaliidae, the fourth in the Globorotaliidae, and the last three in the Anomalinidae.

HEDLEY, R. H. Microradiography applied to the study of Foraminifera.—Micropaleontology, v. 3, No. 1, Jan. 1957, p. 19-24, pls. 1-4, text fig. 1.—A method of revealing internal structures of whole Foraminifera.

HOFKER, J. Les Foraminifères de la zone de contact Maastrichtien-Campanien dans l'est de la Belgique et le sud des Pays-Bas.—Ann. Soc. Géol. Belgique, tome 80, Dec. 1956, p. 191-233, text figs. 1-79, 2 tables.—Sixty-four species and subspecies, one species new.

Foraminifera from the Cretaceous of southern Limburg, Netherlands. XXII. The development of **Eponides beisseli** Schijfsma.—Natuurhist. Maandblad, 45e Jrg., No. 11-12, Dec. 28, 1956, p. 131, 132, text figs.—Description of evolutionary changes across the Cretaceous-Tertiary boundary.

Foraminifera from the Cretaceous of southern Limburg, Netherlands. XXIII. The development of **Sigmomorphina soluta** Brotzen and of **Sigmomorphina brotzeni** nov. sp.—Natuurhist. Maandblad, 46e Jrg., Nos. 1-2, Febr. 28, 1957, p. 16-19, text figs. 1-27.—Evolution of **S. brotzeni** from **S. soluta** is illustrated.

HOVASSE, RAYMOND. **Arnoldia antiqua,** gen. nov., sp. nov., Foraminifère probable du Précambrien de la Côte-d'Ivoire.—Comptes Rendus des séances de l'Acad. Sci. (Paris), Tome 242, No. 21, May 23, 1956, p. 2582-2584, text figs. 1-5.—A series of agglutinated chambers in linear arrangement and probably attached.

IMANISHI, SHIGERU. Outline of the Tertiary stratigraphy of the Shintotsukawa District, Kabato-gun, Hokkaido.—Kumamoto Journ. Sci., ser. B, No. 2, March 1953, p. 45-58, correl. table, columnar section, geol. map.—Numerous smaller Foraminifera listed from Miocene formations.

KANTOROVA, VIERA. Über die sogenannte Inoceramenkreide in der Umgebung von Snina (German résumé).—Geol. Práce, Zpravy 9, 1956, p. 52-63, pls. 5, 6, map, tables.—Twenty-two species recorded and illustrated.

KOBAYASHI, MANABU. On some new species of **Rauserella** from Mt. Ibuki, Shiga Prefecture, central Japan.—Trans. Proc. Pal. Soc. Japan, n. ser., No. 23, Aug. 31, 1956, p. 225-228, pl. 32.—Three species, one new, one indeterminate, and one questionably assigned to this fusulinid genus.

KOZIKOWSKI, HENRYK, and JEDNOROWSKA, ANTONINA. Geological and micropalaeontological research-work within the Slonica valley (in Polish).—Acta Geol. Polonica, v. 6, No. 4, 1956, p. 403-419, pls. 1-3, text figs. 1-3 (maps), tables 1, 2.—Distribution tables, lists, and photographs of Eocene Foraminifera.

Age problems of the Grybow beds and the so-called "grey Cretaceous" of the neighbourhood of Gorlice (Western Flysch Carpathians) (in Polish).—Przeglad Geol., v. 5, No. 3, 1957, p. 106-111, 3 microphotographs, 1 distribution and abundance chart.—Distribution and abundance in Eocene and Oligocene strata indicated for about 50 species of Foraminifera.

LeCALVEZ, YOLANDE, and FEUGUEUR, LÉON. L'Yprésien France-Belge: Essai de corrélation stratigraphique et micropaléontologique.—Bull. Soc. Géol. France, ser. 6, tome 6, fasc. 6, 1956, p. 735-751, text figs. 1, 2, tables 1, 2.—Evidence of the Foraminifera bearing on the correlation.

LOEBLICH, ALFRED R., JR., and TAPPAN, HELEN. **Woodringina,** a new foraminiferal genus (Heterohelicidae) from the Paleocene of Alabama.—Journ. Washington Acad. Sci., v. 47, No. 2, Febr. 1957, p. 39, 40, text fig. 1.—**Woodringina** (type species **W. claytonensis** n. sp.), a minute planktonic genus.

LONGINELLI, ANTONIO. Foraminiferi del Calabriano e Piacenziano di Rosignano Marittimo e della Val di Cecina.—Palaeontographia Italica, v. 49 (n. ser. v. 19), Anni 1954-56 (1956), p. 99-214, pls. 11-25.—Notes, illustrations (excellent photographs), and table showing distribution and abundance for about 250 species and varieties (12 new) from 8 samples, all but one Quaternary.

MAC GILLAVRY, H. J. Two evolving species of the genus **Lepidorbitoides** Silvestri, a biometrical study.—Meded. Geol. Stichting, n. ser., No. 9, 1955, p. 11-43, text figs. 1-5 (maps, diagrams), figs. I-VIII (graphs), tables I-IV.—**L. socialis** and **L. minor** studied as to number of adauxiliary chambers, size of initial chambers, and number of buddings on the protoconchal side.

MARIE, P. Sur quelques Foraminifères nouveaux du Crétacé supérieur belge.—Ann. Soc. Géol. Belgique, tome 80, Dec. 1956, p. 235-257, pls. 1-3.—Twelve new species included in 10 genera of which 3 are new: **Plectinella** (genotype **P. virgulinoides** n. sp.), **Enantioamphicoryna** (genotype **E. obesa** n. sp.), and **Rectobulimina** (genotype **R. carpentierae** n. sp.).

MARKS, P. Smaller Foraminifera from Well No. 1 (Sumur 1) at Kebajoran, Djakarta.—Republik Indonesia, Publ. Keilmuan Nr. 30, ser. Paleo., 1956, p. 1-47, pls. 1-29, map and distrib. chart.—Over 50 species are recorded and illustrated, 1 subspecies new, from 4 narrow marine zones within a 253-meter thickness of Pleistocene delta deposits. Presence and absence of Foraminifera, indicating transgressions and regressions of the sea, aid in the subdivision of the Pleistocene.

McGUGAN, ALAN. Upper Cretaceous Foraminifera from Northern Ireland.—Journ. Pal., v. 31, No. 2, March 1957, p. 329-348, pls. 31-35, text figs. 1-4 (map, sections, range chart).—About 65 species, none new, are illustrated. Notes on about half of them are included, and paleogeographic interpretation discussed.

NAKKADY, S. E. Biostratigraphy and inter-regional correlation of the upper Senonian and lower Paleocene of Egypt.—Journ. Pal., v. 31, No. 2, March 1957, p. 428-447, text figs. 1-3, table 1.—Ranges of many species of Foraminifera are indicated and discussed. Lower Paleocene age for the Danian is supported.

NATLAND, M. L. Paleoecology of West Coast Tertiary Sediments, Chap. 19 **in** vol. 2 (Paleoecology), Treatise on Marine Ecology and Paleoecology.—Geol. Soc. America, Mem. 67, v. 2, March 25, 1957, p. 543-572, pls. 1-6, text figs. 1, 2.—Interpretations are based in large part on Foraminifera.

NORVANG, AKSEL. The Foraminifera of the Lias Series in Jutland, Denmark.—Meddel. Dansk Geol. Forening, v. 13, pt. 5, 1957, p. 1-135, 16 pls. (figs. 1-182), text figs. 1-5.—From a series of well samples, 69 species and subspecies, 6 subspecies new, are recorded and most of them illustrated. Forms previously referred to **Frondicularia** and **Lingulina** are shown to belong to **Spandelina** and **Geinitzina** of the Nodosinellidae. Included in the paper are historical review, discussion of classification, and phylogenetic results with several evolutionary lines shown. Correlation is made with the German and English Lias.

NYHOLM, KARL-GEORG. Orientation and binding power of Recent monothalamous Foraminifera in soft sediments.—Micropaleontology, v. 3, No. 1, Jan. 1957, p. 75, 76, text fig. 1.—Living positions (perpendicular or parallel to the sediment surface) and types of pseudopodia (rigid or fragile) affect bottom conditions.

OBERHAUSER, RUDOLF. Ein Vorkommen von **Involutina liassica** (Jones) im Distrikt Eskisehir.—Bull. Geol. Soc. Turkey, v. 5, No. 1-2, Oct. 1954, p. 203-205, 1 pl.

Neue mesozoische Foraminiferen aus der Türkei.—R. v. Klebelsberg-Festschrift, Geol. Gesellschaft Wien, Mitteil., Band 48, 1955 (1957), p. 193-200, pl. 1, text figs. 1-3.—A new species of **Kilianina** and a new subgenus of **Trocholina**, **Paratrocholina** (subgenotype **P. oscillens** n. sp.).

PERIN, GIOVANNI. Studio micropaleontologico dei terreni miocenici del Friuli Occidentale.—Mem. Accad. Patavina di SS. LL. AA.: Cl. Sci. Mat. e Nat., v. 68 (1955-56), 1956, p. 3-13, 2 pie diagrams.—Lists of species and percentage comparison by genera between Langhian and Helvetian.

PHLEGER, FRED B, and PARKER, FRANCES L. Gulf of Mexico Foraminifera.—Fishery Bull. 89, Fish and Wildlife Service, v. 55, 1954, p. 235-241, text figs. 55-59.—A summary of information concerning distribution and depth ranges of species.

PLÖCHINGER, B., and OBERHAUSER, R. Ein bemerkenswertes Profil mit rhätisch-liassischen Mergeln am Untersberg-Ostfuss (Salzburg).—Verhandl. Geol. Bundes., 1956, heft 3, p. 275-283, 1 text fig.—Numerous Foraminifera are listed.

Die Nierentaler Schichten am Untersberg bei Salzburg.—Jahrb. Geol. Bundes., Jahrg. 1957, Band 100, heft 1, p. 67-79, text figs. 1, 2, 1 table.—Foraminifera, including many **Globotruncana**, are listed.

RAUSER-CHERNOUSSOVA, D. M. On the impossibility to qualify **Borelis princeps** Ehrenberg, 1854, as a species typical of the genus **Schwagerina** Moeller, 1877 (in Russian).—Doklady, Akad. Nauk SSSR, Tom 111, No. 6, 1956, p. 1333-1335.

REYNOLDS, M. A. The identification of the boundary between Coal Measures and Marine Beds, Singleton-Muswellbrook District, New South Wales.—Australia Bur. Min. Res., Geol. Geophysics, Rept. No. 28, 1956, p. 1-35 (mimeographed), figs. 1-3, tables 1, 2, 2 maps.—Includes numerous lists of Permian Foraminifera by IRENE CRESPIN.

RUSCELLI, M. La serie aquitaniano-elveziana del Rio Mainia (Asti). Parte II. Descrizioni paleontologiche.—Riv. Ital. Pal. Stratig., v. 62, No. 2, 1956, p. 63-108, pls. 2-8.—Microfaunas of the Aquitanian, Langhian, and Helvetian stages are studied. Fifty-eight species and varieties, 5 indeterminate, are discussed and illustrated.

SAID, RUSHDI, and BARAKAT, M. G. Lower Cretaceous Foraminifera from Khashm el Mistan, northern Sinai, Egypt.—Micropaleontology, v. 3, No. 1, Jan. 1957, p. 39-46, pl. 1, text figs. 1-2, table 1.—Thirty-three species (10 new and 5 indeterminate) from Aptian rocks.

SALVATORI, U. I coralli ed i foraminiferi del Miocene inferiore di M. Curlo (Voghera).—Riv. Ital. Pal. Stratig., v. 62, No. 2, 1956, p. 125-132, pl. 12.—Foraminifera from a lower Miocene coral locality.

SAUNDERS, JOHN B. Trochamminidae and certain Lituolidae (Foraminifera) from the Recent brackishwater sediments of Trinidad, British West Indies.—Smithsonian Misc. Coll., v. 134, No. 5, March 15, 1957, p. 1-16, pls. 1-4.—Eight species, 1 new, in 6 genera, 2 new. **Siphotrochammina** n. gen. (type species **S. lobata** n. sp.) and **Tiphotrocha** n. gen. (type species **Trochammina comprimata** Cushman and Bronnimann). The genus **Trochamminita** is emended.

SHUTSKAIA, E. K. Stratigraphy of lower horizons of Paleogene of central Caucasus according to Foraminifera (in Russian).—Akad. Nauk SSSR, Instit. geol. nauk, Trudy, vyp. 164, 1956, p. 3-119, pls. 1-5, text figs. 1-3, tables 1-20.—Twenty-one species, 9 new, and 4 varieties, 3 new, are described in Russian and illustrated. Numerous distribution tables and range charts are included.

SZÖTS, ENDRE. L'Éocène (Paléogène) de la Hongrie—Étude Stratigraphique et Paléogéographique (in Hungarian with French and Russian summaries).—Geol. Hungarica, ser. Geol., Tom. 9, 1956, p. 1-318, pls. 1-22 (maps, diagrams), tables 1-3.—Foraminifera, mainly nummulites, are used in the study.

TEMPÈRE, CLAUDE. Quelques applications des biofaciès a l'étude stratigraphique et paléogéographique du bassin néogène du Bas-Chélif (Algérie Occidentale).—Bull. Soc. Géol. France, ser. 6, tome 6, fasc. 6, 1956, p. 727-734, text figs. 1, 2.—Foraminifera genera are used in interpreting and distinguishing between 5 different biofacies.

THOMPSON, M. L. Rocas Paleozoicas del Sur de Mexico.—20th Internat. Geol. Congress, Mexico, 1956, Excursion C-15, p. 61-73, pls. 1, 2.—Fusulinids are illustrated.

Northern midcontinent Missourian fusulinids.—Journ. Pal., v. 31, No. 2, March 1957, p. 289-328, pls. 21-30, text figs. 1, 2.—Eighteen species (4 new) in 5 genera. One genus and 2 subgenera are new: **Kansanella** n. gen. and n. subgen. (type species **K. (K.) joensis** n. sp.) and **Iowanella** n. subgen. of **Kansanella** (type species **Triticites winterensis** Thompson, Verville, and Lokke).

TODD, RUTH, and BRONNIMANN, PAUL. Recent Foraminifera and Thecamoebina from the eastern Gulf of Paria, Trinidad.—Special Publ. No. 3, Cushman Found. Foram. Res., April 30, 1957, p. 1-43, pls. 1-12, text figs. 1-7 (maps, graphs), tables 1-5.—About 200 species of Foraminifera and 9 of Thecamoebina are recorded and illustrated and their abundance in 3 zones indicated. Ecologic conditions are discussed. Ten new species of Foraminifera are described.

VALENTI, ITALO. Studio dei foraminiferi di due giacimenti pliocenici della Provincia di Imperia.—Mem. Accad. Patavina di SS. LL. AA.: Cl. Sci. Mat. e Nat., v. 67 (1954-55), 1955, p. 3-9, text fig. 1 (graph).—Lists of Foraminifera.

VAN VEEN, F. R. Microforaminifera.—Micropaleontology, v. 3, No. 1, Jan. 1957, p. 74, text figs. 1-4.—Survival in residues of Recent bottom samples after HCl treatment indicates presence of an acid-resistant inner lining in Foraminifera.

VERVILLE, G. J. Wolfcampian Fusulinids from the Tensleep sandstone in the Big Horn Mountains, Wyoming.—Journ. Pal., v. 31, No. 2, March 1957, p. 349-352, pl. 36.—Two species of **Triticites** and one of **Schwagerina**, all indeterminate.

VILLA, F. A. Microfaune e Microfacies del Nummulitico di Travedona (Varese).—Riv. Ital. Pal. Stratig., v. 62, No. 2, 1956, p. 109-124, pls. 9-11.—Foraminifera indicate middle Eocene age.

WETZEL, OTTO. Fossil "microforaminifera" in various sediments and their reaction to acid treatment.—Micropaleontology, v. 3, No. 1, Jan. 1957, p. 61-64, pl. 1.

WICHER, CARL A. Die mikropaläontologische Gliederung des nichtmarinen Keuper.—Erdöl und Kohle, 10. Jahrg. [1957], p. 3-7, pls. 1-3, text figs. 1, 2.—Two foraminifers (**Ammodiscus** and **Proteonina**) with a fauna of ostracodes and spores in the Triassic.

WICHER, CARL A., and BETTENSTAEDT, FRANZ. Sur Oberkreide-Gliederung der bayerischen Innviertel-Bohrungen.—Geol. Bavarica, No. 30, Jan. 1957, p. 3-54, text figs. 1-3.—Development of **Bolivinoides** based on length-breadth index. **Ventilabrella deflaensis** Sigal in the Santonian.

YAMAGIWA, NOBUS. Neoschwagerininae from the Shima Peninsula, Japan.—Trans. Proc. Pal. Soc. Japan, n. ser., No. 23, Aug. 31, 1956, p. 235-242, pl. 34, map.—Four species, three new.

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